# REASSESSMENT OF THE mini-SASS BIOMONITORING TOOL AS A RESOURCE FOR ENVIRONMENTAL EDUCATION IN THE RIVER HEALTH PROGRAMME AND CROSS-LINKING TO WITH THE NATIONAL CURRICULUM STATEMENT

Report to the
**Water Research Commission**

by

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(WRC Project No. K8/733).

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# Introduction

Reliable indicators of water quality and river health are often difficult and expensive to derive. The development of the miniSASS tool during the late 1990s was a low technology, scientifically reliable and robust technique to monitor water quality in rivers and streams. miniSASS was the development of a simplified method of biomonitoring based on the tried and tested SASS (South African Scoring System)

technique. This involved reducing the taxonomic complexity of SASS to a few aquatic invertebrate groupings which would act as surrogates for the complete suite of SASS taxa.

A recent River Health Programme (RHP) Symposium held in Pretoria identified a clear need to upgrade the miniSASS as a community and environmental education resource tool, that had clear linkages to the River Health Project and which could assist in the national drive to Adopt-A-River.
In a review of the miniSASS tool (version 1) it was recognised that there was a need to reassess the current miniSASS tool based on current users and in the same way as SASS went through various iterations and refinements over the years, revise the current version of miniSASS and attend to its perceived shortcomings whilst aligning it with the objectives of the RHP and the National Curricula where applicable. In short this project looked at critically auditing the current miniSASS tool for perceived and real shortcomings and upgrading the tool to a miniSASS version 2. The contracted deliverables which were expected from this project were the following:

- an updated and revised miniSASS tool,
- lesson plans which have river health as a central theme and using miniSASS as a central tool for these lessons and
- a feasibility assessment for web based entry of miniSASS data.

In order to achieve this, a thorough audit/survey was conducted of users perceptions, needs and expectations of the current version of miniSASS (version 1). These findings were summarized and used to address the key limitations identified by the audit in conjunction with the national RHP and the formal environmental education staff at relevant institutions (e.g. the WESSA and Lydenburg Environmental Centre.) A workshop was also conducted to enlarge on the needs or expectations of the resource and then to refine the miniSASS tool so that it was more closely aligned to users expectations and needs.

This short report documents the progress and achievements in addressing the deliverables for this project, viz. K8/733. However, the key output from this work has been the refinement of the miniSASS tool to a version 2 level, and the development of resource materials to support educators in addressing water related themes in the formal and informal education arena (and linking these directly through to the National Curriculum Statement). These deliverables are stand alone products and available for distribution independent of this report.

An honours thesis was an unexpected and additional capacity building element which arose from this project. The full title of the thesis (copy attached as an appendix to this report) was:
***The miniSASS tool: An investigation of its short comings and limitations and suggestions for its improvement***. Imke Summers, Discipline of Geography, School of Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg.

# Summary of deliverables

## *Audit of the miniSASS version 1 tool*

To address the first key deliverable of this project, i.e. **an updated and revised miniSASS tool**, an audit process was undertaken with a number of environmental education practitioners.

The process was started off with a workshop held at the WESSA Environmental Centre in Howick in the KZN Midlands on the 18th April 2008. It was attended by 15 river health practitioners and environmental educators, all of which had had some exposure to the miniSASS tool. The tool was discussed and its limitations identified. These limitations along with further suggestions were then used to develop a closed ended questionnaire concerning the miniSASS tool. A closed ended questionnaire format was chosen to limit the variability of the responses and to enable the gathering of statistical data.

A pilot study of the questionnaire was run, with all those that had been present at the workshop. The responses from the pilot study, in conjunction with advice from a number of academics and specialists, were used to produce the final closed-ended questionnaire. The questionnaire was e-mailed to the over 900 people who were on the WESSA database. The completed questionnaires were then tabulated and quantitatively and qualitatively analysed. The analysis was then used to inform suggestions as to the limitations with miniSASS and possible improvements that could be made to the tool.

Suggestions included the need for clearer line drawings, up to date contact details, clearer directions regarding the methodology and scoring, more information regarding the history of miniSASS and, details for further reading to encourage the dissemination of knowledge public participation. Suggestions for translating the tool into other official languages as well as producing a more simplified miniSASS for young children were put forth. However further research needs to be conducted in these fields to determine their viability.

The key findings from the audit process were then used to address the shortcomings in the miniSASS version 1 tool and used in the refinement and production of the miniSASS version 2 tool.

## *Updated/revised miniSASS tool – miniSASS version 2*

Having identified the shortcomings of the miniSASS version 1 tool in the audit, the next step in addressing the specific first deliverable of this project, i.e. **an updated and revised miniSASS tool**, was to produce a version 2 of the tool which addressed as far as was practicable, and within the constraints of the project, the real shortcomings of the version1 tool.

The new tool (version 2) has been divided into two separate pamphlets; an information pamphlet and a field guide (attached to this report as appendices). The information pamphlet contains the history of miniSASS, a step-by-step methodology, information regarding the importance of water quality monitoring and management in South Africa, a glossary, key-words and sites for further reading, step-by-step instructions for the scoring, and up-to-date contact details. The field guide contains a dichotomous key which will aid in the identification of the macroinvertebrates, new line-drawings and, some additional general information on macroinvertebrate feeding habits and diet.

Additionally a complete reworking and statistical investigation of the quality value (QV) scores assigned to each miniSASS macroinvertebrate group was undertaken. This was based on over 6000

SASS records extracted from the national Rivers Database and used to verify and refine quality values for the new miniSASS version2. This process was also able to allow a simplification of the QV scores to be applied throughout the country and made for an easier and less ambiguous interpretation of the final score calculations for the miniSASS (identified as one of the areas to be addressed during the audit phase of the project).

Version 2 of the miniSASS tool underwent field testing at the WESSA Environmental Centre in Howick by river health practitioners and environmental educators. It was well received by all the participants. A fully downloadable Version 2 of the miniSASS tool will be available on the GroundTruth website http://ground-truth.co.za/, or from miniSASS@ground-truth.co.za, or from the Share-Net/WESSA offices in Howick (contact sharenet@wessa.co.za). The field guide has been put on the CD accompanying this report.

## *Integrated lesson plans using miniSASS*

To address the second key deliverable of this project, i.e. **lesson plans which have river health as a central theme and using miniSASS as a central tool for these lessons,** a suite of integrated lesson plans have been developed based on the National Curriculum. Grades five, seven, nine and eleven have been addressed and each respective grade's plans contain the following activities:

**Grade 5**

**Activity One:** During this **MATHEMATICS** lesson, learners look at the quantity of water used in their homes over a 24-hour period.

**Activity Two:** During this **SOCIAL SCIENCES: GEOGRAPHY** activity, learners look at rainfall distribution in South Africa, and indicate the major users of water in these regions.

**Activity Three:** During this **TECHNOLOGY** lesson, learners make a simple but effective water filter.

**Activity Four:** During these **LANGUAGES** activities, learners are introduced to the aquatic ecosystem. A word search is followed by a reading activity and comprehension.

**Activity Five:** During this **LANGUAGES** activity, learners are introduced to wetland birds, through a reading exercise and comprehension, followed by dictionary skills and a creative exercise.

**Grade 7**

**Activity One:** In this **LANGUAGES** activity, learners research and find out more about river water quality in their area. A newspaper article forms the focus point for a general class debate around river health.

**Activity Two:** During this **NATURAL SCIENCES** lesson, learners investigate the water quality of a nearby river, using the miniSASS toolkit to look for visible animal life.

**Activity Three:** During this **NATURAL SCIENCES** lesson, learners categorise the water macroinvertebrates that they found in Activity Two and create their own dichotomous key.

**Activity Four:** During this **ARTS AND CULTURE** drama activity, learners follow a teacher-directed warm-up routine. They also mimic the behaviour of some of the water creatures they found during the miniSASS activity earlier.

**Activity Five:** Water can make things look bigger than they really are. This "Just For Fun" activity gives full instructions for making a magic magnifier (convex water lens.)

**Grade 9**

**Activity One:** In this **LANGUAGES** activity, learners find out more about the state of South Africa's rivers. A newspaper article forms the focus point for a general class discussion around river health.

**Activity Two:** Following on from Activity One on river health, learners investigate suitable equipment needed for water quality monitoring in a local river or body of water. During this **TECHNOLOGY** lesson, they will design, cost and build some of the necessary equipment.

**Activity Three:** During this **NATURAL SCIENCES** exercise, learners investigate the water quality, based on visible animal life, of a nearby stream, river or body of water. They use the miniSASS toolkit and their equipment from Activity Two to undertake this activity.

**Activity Four:** During this **MATHEMATICS** activity, learners find out how water finds its way to the taps in their homes. They also collect and summarise information on two important South African laws around the provision of water services.

**Activity Five:** During this **NATURAL SCIENCES** lesson, learners develop a River Action Plan with aims, goals and objectives. They then implement the Action Plan, evaluate it and review it.

**Grade 11**

**Activity One:** During this **LIFE SCIENCES** activity, learners look at how animal life can be used to determine the health of rivers and streams.

**Activity Two:** During this **SOCIAL SCIENCES: GEOGRAPHY** lesson, learners look at how climate change may impact upon water quality in South Africa.

**Activity Three:** During this **LANGUAGES** lesson, learners compare various methods of water quality assessment and answer a comprehension on water quality assessment using diatoms.

**Activity Four:** During this **PHYSICAL SCIENCES** lesson, learners look at the impacts that abiotic factors have on water quality.

**Activity Five:** During this **LIFE SCIENCES** lesson, learners look at the impact that dams have on aquatic organisms.

## *Feasibility assessment for web entry of miniSASS version 2 data*

The objective of this part of the report was to determine possible ways that individuals may submit miniSASS results so that they may be integrated into a central database. A key aspect of the central database will not only be to enter data, but also to allow for increased recognition of the miniSASS technique on a national and potentially African/global scale to allow water quality monitoring to take place using simple biomonitoring tools. However, entering data in this regard has various constraints and limitations and these will be discussed in more detail. Submitting data to a central database is an important step to be included with the integration of miniSASS into schooling curriculum given the potential degree of data submissions that are expected from the schooling sector, i.e. the potential for every school in the country and in every catchment to become part of a network of river health monitors.

## Capturing, submitting and sharing of miniSASS vers 2 data

miniSASS data capture and submissions are separated into three core areas, namely; capturing miniSASS results and site details, submitting the data to a central location, and sharing the results more widely. These are discussed in the following phases:

**PHASE 1** – Basic capture of miniSASS data and study site information

The following steps form the basis of Phase 1:
A miniSASS assessment is conducted following the determination of a river system that requires assessing and locating a suitable site that provides an adequate representation of the river. Selection of an appropriate site may be limited by various factors, such as landscape features, access, and safety.
At the site, a miniSASS assessment is conducted to measure and record the required information according to the sampling protocol defining the miniSASS technique using the data capture sheets.
Site information is also noted during the procedure, most importantly of which is to record the coordinates of the site. For this, a GPS receiver should preferably be used making sure that the coordinate system and number format has been correctly set up in terms of the format needed for miniSASS (i.e. datums for South Africa, e.g. WGS84 and Cape, and coordinate formats, e.g. degrees minutes seconds and decimal degrees). In circumstances where a GPS is not available, alternative options for recording site coordinates may be used, e.g. topographical maps, Google Earth, etc. This may be done back at the office, class room, computer LAN. However, caution needs to be exercised given the likelihood of errors with extracting coordinates. Again, it will need to be ensured that the correct coordinate format is used.
Once a field survey has been completed successfully and the data capture sheets properly filled in, the assessor may proceed to the next step, which is to send the data to a central location where the result may be input into the miniSASS database. This essentially is the basis for Phase 2.

**PHASE 2** – Submission of miniSASS results

All miniSASS results ideally should be submitted to a central destination where the results are gathered, checked, and stored. However, getting the data to a central database location presents various problems due to the variety of options that may be used to facilitate a submission. These range from simply faxing a raw data sheet, to more complicated web-based data entry system. Once data has been submitted there are additional issues that would need to be considered for entering data into the miniSASS database. For situations where data sheets are faxed directly through, personnel would be required to manually input the data into the databases, whereas a more web-based data entry would reduce the need for numerous data capture personnel with only a few skilled technicians to conduct quality control and data integrity checks.
Once the miniSASS data has been input into the central database, it would be useful to have the results available to national and even global communities. This opens up opportunities for miniSASS results to becoming freely accessible through the web-based interfaces.

**PHASE 3** – Sharing of results with national and international communities

If miniSASS data is simply entered into a database where it is merely stored and only used for limited analysis, it would have less of an impact than if the results were made available to anyone with the views of understanding a particularly river system that may or may not have been assessed. Thus the greatest benefit is possible from this tool if the data is made freely available for interpretive reasons. miniSASS results from the database could be shared using various media on the web. This could be achieved either through accessing summary results from the miniSASS web site, by searching either by river name or by study site coordinates, or by interfacing the database with

conceptually-based mapping tools such as Google Earth or other more complex web mapping software such as ArcGIS/IMS. This would allow any person, with a reasonable understanding of river ecology, to determine the state of a particular river system based on the network of river monitors (miniSASS operators) within a catchment or area.

### Options for submitting and sharing data

As already mentioned, there are various ways by which miniSASS data may be submitted to a central database, stored, and then shared with some options being more efficient than others. Table 1 below summarises the different options, their advantages, disadvantages, and estimated costs. Each approach is rated based on their attributes and classified as being either a good, moderate or poor option for further investigation/pursuit. There are numerous other possible hybrid models between these various options.

Table 1: Summary of possible data entry routes for miniSASS data.

| | Options | Advantages | Disadvantages | Estimated annual costs[1] | Rating |
|---|---|---|---|---|---|
| 1 | ArcGIS (IMS) | Produces dynamic, highly scalable maps via the web.<br><br>Allows for sharing of information within organisations and to the public.<br><br>Easy to install and set up.<br><br>Supports a wide variety of data formats.<br><br>Offers strong data integration capabilities.<br><br>Use of ESRI data and maps. Maintenance included with the first year.<br><br>Training, technical support, and other resources are provided. | Costs for purchase is high. Requires a decent web server.<br><br>Requires ArcGIS if one requires metadata services.<br><br>Technical person is needed to integrate data into the IMS interface. | R 100 000 | Poor |
| 2 | Google Earth | Is available at no cost. Simple to use and data is easily inserted and manipulated. | To effectively use Google Earth, a computer system with reasonable processing and memory is required as well as a | R 10 000 | Good |

[1] Includes: Software, HR resource to run and manage database, data entry, etc.

| | | | | | |
|---|---|---|---|---|---|
| | | Uses up to date, high resolution aerial and satellite imagery.<br><br>Allows a user to interactively locate areas of interest and identify land cover features.<br><br>Capable of measuring areas, calculating distances, and inserted themes either as points, lines and polygons.<br><br>The integrity of coordinate data and its spatial orientation is easily assessed.<br><br>Highly recognised tool and easily available given it strong capabilities for wide-spread sharing of data.<br><br>Has the potential to improve with advances in computer and internet technology. | decent internet connection.<br><br>For additional processing, Google Earth Professional is needed, which comes at a cost.<br><br>Reasonable skills needed to upload data into Google Earth. | | |
| **3** | No data entry (individuals collect samples/data but do not submit them to a central repository | Easily managed | Loss of potentially valuable data | R 0 | **Poor** |
| 4 | Email | Potential for built-in data quality control and integrity checks.<br><br>Problematic data is easily traceable back to its source. | | R 4000 | **Moderate** |
| 5 | Fax/snail mail | Easiest method of data submission, particularly for individuals without access to the internet. | Risk of misinterpretation of datasheets.<br><br>Time consuming and requires a third party for data input. | R 4000 | **Moderate** |

### The early miniSASS version 1 web site

The previous web site for miniSASS provided the opportunity for all sites to be mapped, which could then be viewed over the web. This was made possible through a third party that captured and stored the data in a way that data was made available on the web. However, there were several shortcomings with this approach which included:

- The maps were very basic in that they only worked on topographic sheet indexing, displaying vector data. This made it very difficult to identify a site due to the rather poor base mapping process.
- A technically-minded person was required to create and maintain the mapping creation and conversion to web. This required some GIS tools as a requirement.
- There was no instant feedback to contributors of the site data.
- There were potential positioning problems from GPS coordinates misread or incorrectly captured.
- There was a hosting service provided for this web mapping. This came at a recurring cost.

### Other non-spatial solutions.

Developing a web-based solution for miniSASS.

The following minimum requirements are seen as important for developing a web-based approach to miniSASS:

- Allow the miniSASS sites to be shown on a map.
- The sites can be queried to show some basic data about the sites, particularly key miniSASS readings (river health status of the monitoring sites) and dates sampled.
- A suitable labelling convention is needed to allow for efficient location of a site.
- Enable users access to the miniSASS site to capture field recordings directly to the web page, which will then be amended to maps on a regular basis.
- Maps should be easily accessed by the public domain to allow freedom to interpret results obtained for various sampled river systems.
- The spatial data sets that would be required should include, at the least, sample sites and rivers and to a lesser degree base data, such as imagery, roads, towns, etc.

In order to achieve the aforementioned minimum requirements, thus improving the conceptual presentation and overall efficacy of the miniSASS approach, it would be important to determine which options best fit the requirements. The following conditions should be considered in order to facilitate the selection of an appropriate option:
For each sample site there will need to be the associated miniSASS data - indicated as captured from the field assessments. Furthermore, the readings, when depicted on a map, need to be discernable. Ideally this would be achieved using appropriate symbolisation to reveal the underlying information graphically, using various colours and symbols, and spatially by the indicating the geographic position. A simpler solution would be having all information for each site visible as a user pans over an area. This can however be translated to the rivers which in turn could be symbolised and stylized, i.e. a “healthy” river is symbolised as BLUE and an “unhealthy” river as RED. This in turn can be translated to symbology for catchments and subcatchments, etc.

Based on the requirements for improving the miniSASS through a web-based approach, it is noted that Google Earth offers the greatest potential to display miniSASS data within a spatial framework. However, to ensure that the process of data capture is carried out effectively, it is important that the individual conducting the assessment has all the necessary field materials, which should at least consist of the following, a pen, miniSASS data sheet, and a decent map that enables the user to locate the site in Google Earth. The most suitable situation will be for those individuals that make use of a GPS receiver to record the site coordinates, which then ensures the site is accurately

marked on Google Earth. Alternatively the users would need to post locate themselves after their field trip within Google Earth. From this they could retrospectively insert their sample coordinates onto their field sheets.

An additional advancement to miniSASS data capture would be to develop a system of web-based data capture by having a form on the miniSASS web site that allows the user to input the data obtained from their respective sampling site. The information (coordinates, river health status, etc.) that is uploaded may then be automatically stored into the central database. However, it will be important to ensure that potential errors are limited to improve the quality of data in the database. For example, it is possible for just the capturing of site coordinates to be incorrect through the use of wrong projections and coordinate formats. Thus it is critical that data quality checks are implemented to prevent cases of erroneous data being inserted to a database.

## *Post Project note*

A meeting is scheduled for 16/17 April with WWF and the Mondi Wetlands programme with a view to taking forward the proposal to place the project on Google Earth. Thereafter an approach will be made to Google Earth to determine what might be possible in this respect.

**The developed materials accompanying this report are the following:**

- **CD – containing Lesson plans and final Mini Sass Booklet**
- **Hard copies of the lesson plans**

# Appendix I: Honours Thesis Project – Ms Imke Summers

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## The miniSASS tool: An investigation of its short comings and limitations and suggestions for its improvement

**Imke Summers**

**Discipline of Geography**
**School of Environmental Sciences**
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**Pietermaritzburg**

## Abstract

The miniSASS tool is a water quality analysis tool that measures macroinvertebrate presence to determine river health. It has been adapted from the more complex SASS5 tool. In recent years a number of limitations with the tool have been raised. Thus there is a need to identify what the limitations are and to suggest possible ways in which these issues could be mitigated. This was achieved through a participation process that included a miniSASS workshop at which the perceptions, needs and expectations of miniSASS users were identified; the consequent development of a questionnaire which was sent out to over 900 individuals, and the analysis of miniSASS field data to determine whether field work can enhance decision making. Results indicated that the public concur that there are limitations with the tool, but that they can be rectified through a number of factors. These include the use of less text, clearer identification diagrams of the macroinvertebrates and a more defined methodology. Suggestions for placing the miniSASS tool in a broader, national context were also put forward. Secondary results also showed that field work is vital in understanding the limitations of the tool and that the health of a river system cannot be generalised from a few samples. It is hoped that the recommendations that have been suggested will help in making miniSASS a water quality analysis and management tool that can be used in the greater South and southern African context.

## Introduction

Everyone depends on water for survival-it is essential for life, well-being and economic prosperity. It is so important and used in so many ways, that if overused, we risk damaging our very life source (Palmer, 2005). Thus, in recent years the world has seen a proliferation of techniques used to monitor and measure the health of water bodies. These techniques vary from chemical testing, to biotic indices and physical variables. Yet the trend in recent years has been to use benthic macroinvertebrate fauna as an indicator for the quantitative and qualitative classification and analysis of freshwater systems (Stein *et al,* 2007). These bioassesment techniques are used for the assessment of general river conditions and health, as influenced by a variety of factors, the principal one of which is water quality.

South Africa has produced numerous water quality analysis techniques that are based on the study of macroinvertebrates. Initial studies were conducted using a Biotic Index. Following this numerous other techniques were developed, the most influential of which was the South African Scoring System (SASS) technique. This, in turn, evolved through several processes of refinement, receiving the input of numerous practitioners and experts throughout South Africa. After a number of years of refinement a SASS 5 version (See Appendix 1) was developed that was a fast and cost-effective biomonitoring measure. The method has become the standard for the rapid bioassessment of rivers in southern Africa and now forms the backbone of the National River Health Programme (Dickens & Graham, 2002).

However SASS 5 is targeted at water quality specialists and those that are familiar with the identification of macroinvertebrates. Thus a simplified biomonitoring tool that was scientifically reliable, robust and of a low technology was required. This simplified tool was modelled on the SASS5 tool from which the taxonomic complexity of SASS5 was reduced to a few aquatic invertebrate groupings, i.e. from ninety different classes, to thirteen concise classes. What resulted was the miniSASS tool (See Appendix 2). Since its creation, in the late 1990s, the miniSASS tool has been used successfully, throughout South and southern Africa by schools, environmental centres and the general public, as a biomonitoring tool. Over this time various shortcomings and perceived limitations have been raised.

**Aim and objectives**

The aim of the research was to identify the shortcomings and limitations of the miniSASS tool and to suggest ways in which the tool could be improved.

This was achieved by:

- holding a miniSASS workshop that identified the perceptions, needs and expectations of miniSASS users.
- using the feedback from the workshop to develop a questionnaire that was sent to all members on the Wildlife Environmental Society of Southern Africa's (WESSA) e-mail system.
- gathering the opinions of environmental educators who used the miniSASS for the first time at WESSA Environmental Educators course.
- analysing the completed questionnaires to determine the shortcomings and limitations of the miniSASS tool.
- recommending a number of improvements/ alterations to the miniSASS tool.

A secondary aim of the research was to determine if the use of miniSASS in the field could inform any decision making on the improvements/alterations thereof, and if any understanding of the rivers on which the study was implemented could be gained from statistical analysis of the miniSASS results.

This was achieved by:

-conducting miniSASS studies on rivers in Pietermaritzburg.
-and statistically analysing them using a Correspondence Analysis Bi-plot.

## Methods

### Questionnaire

To assess the attitude of the users of the miniSASS towards the tool it was necessary to gather their opinions on the possible limitations and shortcomings, and how these problems could be rectified. A workshop was held at the WESSA Environmental Centre in Howick on the 18th April to discuss the miniSASS tool. Fifteen environmental educators and river health practitioners were present, all of which had had some exposure to miniSASS. The tool was discussed and a number of suggestions were put forward. These suggestions were then used to develop a closed ended questionnaire concerning the miniSASS tool. A closed ended questionnaire was used so that responses could be tabulated and analysed without there being too great a variance in the responses. In some instances though "questionnaires illustrate, and perpetuate, the ideology of the questionnaire designer more than the insights of the respondents" (Taylor pers. comm. 2008). To overcome this, a pilot study of the questionnaire was run with all those that had been present at the workshop. The responses from the pilot study, in conjunction with advice from a number of academics and specialists, were used to produce the final closed-ended questionnaire (See Appendix 3). The questionnaire was e-mailed to the over 900 people who were on the WESSA database. The respondents were given a month to return the completed questionnaires. In addition an Environmental Educators (EE's) course was held at WESSA in Howick on the 9th September at which the miniSASS was discussed at length. The EE's then used the tool for the first time in the field and problems, techniques and responses were recorded by myself. Following this, the completed questionnaires were tabulated and quantitatively and qualitatively analysed. The analysis was then used to inform suggestions as to the limitations with miniSASS and possible improvements.

### Statistical analysis

Five miniSASS tests were run on two different rivers (the Dorpspruit and the Foxhillspruit) in the Pietermaritzburg region. These rivers are surrounded by residential areas and flow through the city. Two of the five miniSASS tests were conducted personally, with the other three tests being conducted by first time users. Their sampling techniques and responses were noted. The results were then tabulated in Excel. Following this, the CANOCO 4.5 statistical package (ter Braak & Šmilauer, 2002) was used to create a Correspondence Analysis Bi-plot which contrasted site composition and macroinvertebrate presence.

## Results

### Questionnaire

Of the 900 plus people to whom the questionnaire was sent via e-mail, less than 25 responded, and only 15 were completed questionnaires. Therefore, the sampled group is very small and the results are not necessarily representative. However, no other data was available and as such the results are based on these findings.

**Table 1.** Demographic profile of the respondents.

| → | Organisation | Home Language | Locality | No. of users |
|---|---|---|---|---|
| NGO | 1 | | | |
| WESSA | 8 | | | |
| School | 2 | | | |
| EEC | 3 | | | |
| Other | 1 | | | |
| English | | 12 | | |
| Afrikaans | | 3 | | |
| Xhosa | | 1 | | |
| Zulu | | 1 | | |
| Sotho | | 1 | | |
| Urban | | | 4 | |
| Semi-urban | | | 7 | |
| Rural | | | 4 | |
| Highest no. | | | | 40/month |
| Lowest no. | | | | 4/year |

**Table 2.** Responses to miniSASS questionnaire.

| **Questions** | **Responses** | | | | |
|---|---|---|---|---|---|
| * | (%)Yes | (%) No | (%) Maybe | (%) Easily | (%) Not easily |
| 1. Is the current A5 pamphlet a good size for working with? | 86 | 4 | | | |
| 3a.Is the layout functional and easy to understand? | 69 | 31 | | | |
| 5. Should the introduction be shortened? | 33 | 67 | | | |
| 6a. Should the methodology be simplified? | 50 | 50 | | | |
| 7. Would two separate documents (i.e. an identification manual/field guide and an information pamphlet) be more practical than the current pamphlet? | 46 | 54 | | | |
| 8a. Is enough information given to complete the necessary task? | 43 | 57 | | | |
| 9. How easily are the invertebrates identified from the drawings? | | | | 54 | 46 |
| 10. Would a dichotomous key make ID easier? | 60 | 10 | 30 | | |
| 11. Should a list of necessary equipment be mentioned? | 100 | 0 | | | |
| 12. Was the necessary equipment readily available? | 64 | 36 | | | |
| 13. Were alternatives/substitutes for equipment readily available? | 85 | 15 | | | |
| 14. Would instructions on how to make necessary equipment be useful? | 86 | 4 | | | |
| 15. Was river safety ever an issue? | 79 | 21 | | | |
| 16. Is a precautionary note on river safety necessary? | 93 | 7 | | | |
| 17a. Did the users understand why miniSASS was being used? | 93 | 7 | | | |
| 18. Did the participants find miniSASS easy to understand? | 86 | 14 | | | |
| 22. Would a database be used? | 93 | 7 | | | |

| | | | | | |
|---|---|---|---|---|---|
| 24. Should the database be accessible to the general public? | 93 | 7 | | | |
| 25. Would feedback from the database be expected? | 83 | 17 | | | |
| 26. Would reference to other water quality websites be expected? | 100 | 0 | | | |
| 27. Is there a need for a juniorSASS? | 50 | 507 | | | |
| 31. Is it necessary to have contact details that miniSASS users can refer to? | 100 | 0 | | | |

***Refer to Appendix 4 for outstanding results.**

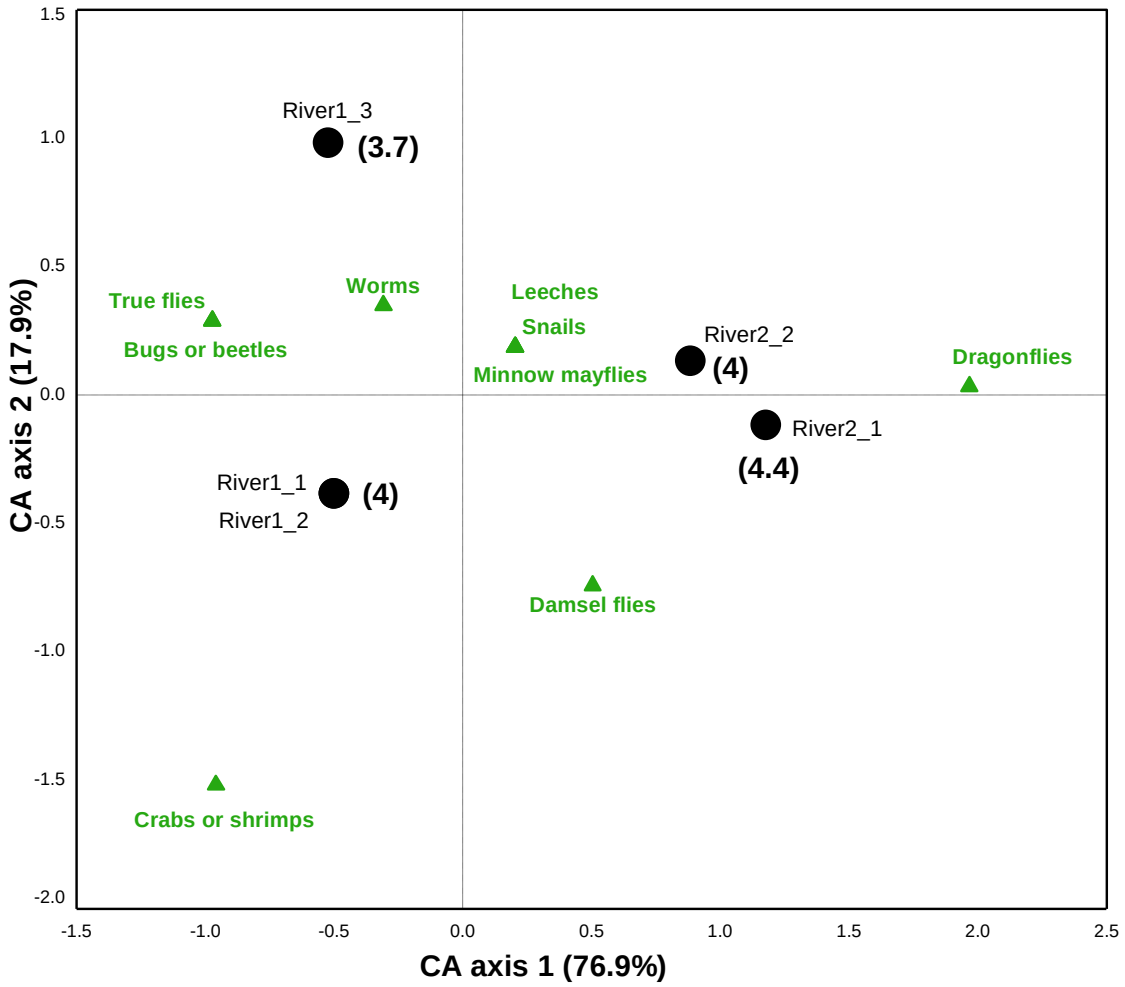


**Figure 1.** Correspondence analysis (CA) bi-plot of the group composition (presence/absence) of five samples collected using the miniSASS tool, from two rivers in Pietermaritzburg, with miniSASS scores in parentheses.

The bi-plot represents data for five samples taken from two rivers, the Dorpspruit (River1_1, 1_2, 1_3) and the Foxhillspruit (River 2_1, 2_2). The bi-plot indicates that the characteristics of a river are not uniform through its entire length. This can be seen from the fact that sample 1.3 for River 1 is significantly distanced from sample 1.1. and 1.2 indicating that the composition of species is different and the river health is dissimilar, i.e. River 1.1 and 1.2 are dominated by crabs and shrimp species whereas River 1.3 is dominated by worms, trueflies and bugs and beetles. All of the species at River sample 1.3 have a low sensitivity score, indicating that they are resilient to pollution. These results correlate with the low miniSASS score of 3.7 (highly impacted stream in poor condition). The bi-plot also indicates that the presence/absence of species for River 2 are very similar due to their proximity to one another. River 2's samples are also dominated by the presence of dragonflies, leeches, snails, minnow mayflies and damselflies. (For raw data see Appendix 5).

## Discussion

### Statistics

The use of statistical analyses for analysing samples of macroinvertebrates is a common practice as can be seen by Elliot (1977), Mackereth *et al* (1978) and Jones (1979). Methods are varied, but in this instance, the use of a Correspondence Analysis (CA) bi-plot using the Canoco 4.5 statistical package was used. Correspondence analysis is a computational method used for the study of associations between variable. It displays a "low-dimensional projection of the data, e.g. into a plain. It does this for two variables simultaneously, thus revealing associations between them" (Fellenberg *et al*, 2001: 10781). The importance of the results lies in the fact that the data show that generalisations regarding river health cannot simply be made from a few samples. Rather they should repeatedly be collected over a period of time or numerous samples should be taken at one site to gain an overall river health indication. Yet results need not always be the same as certain variables such as point source pollution further down river, river flow and vegetation composition next to the river can influence the species found at a particular site. Rather the data can be used to indicate the general health of the river over the sampled area. If results vary it may be due to the variables mentioned, or even due to sampling error. In this instance sampling error may be the main cause of the varying results as the sample collectors were using the miniSASS tool for the first time. Such a concern could be mitigated by specifying the sampling time and techniques used explicitly on the pamphlet.

### Questionnaires

Questionnaires are an inexpensive way of gathering data, particularly from a potentially large number of respondents. Often they are the only feasible way of gathering considerably vast amounts of data so as to perform statistical analyses. Herein lays the first issue encountered with the study. As was noted in the results, less than 25 of the 900 people to whom the questionnaire was sent, completed and returned the questionnaire. The lack of response can be attributed to a number of factors, including people being too busy to complete the questionnaire, people having no previous experience with the miniSASS tool and in some instances, people purely not being interested. In future this issue could be overcome by conducting phone and personal interviews (New, 1998). However, because the sample group needed to have used the miniSASS tool before and because many environmentalists at WESSA have at some stage or another come into contact with it, it was decided that those on the WESSA database would be the most suitable candidates. Compounded by this is the fact that very few people are willing to give out personal details such as phone numbers and thus it could not be expected of the Howick WESSA branch to give these details out. This is also the reason why the questionnaire was sent by a WESSA research assistant in Howick, allowing for no direct contact with the database. The intended sample group was also too large to allow for

individual phone and sample interviews to be conducted and it was not known which of the 900 individuals had or had not used miniSASS before. Hence an e-mail questionnaire was decided as the best option as it was the medium by which the greatest target audience could be met.

**Macroinvertebrates**

Macroinvertebrates are a diverse group of organisms that can live in a myriad of aquatic conditions. They are commonly bigger than 500 micrometers and play a number of important ecological roles. Firstly, they convert and transport nutrients and consequently play an important role in the nutrient cycle. They also convert organic matter into food materials. As they in turn become the main food source for higher aquatic organisms such as fish, they form a basic link between organic matter and higher aquatic animals in the food web (CEE, undated). Their importance as bioindicators lies in the fact that they "are ubiquitous in aquatic systems, they are relatively sedentary (this allows spatial impacts of pollution to be detected), different taxonomic groups have different sensitivities to pollution, they have a rapid life cycle often based on the seasons, they are generally easy to collect and identify and they act as continuous water quality monitors" (Graham *et al*, 2003: p.26). The use of macroinvertebrates for biomonitoring can consequently be used to "assess the spatial and temporal trends in ecological state, assess the ecological state of aquatic ecosystems, assess emerging problems and contribute to the determination of the Ecological Reserve" (Dickens & Graham, 2002). All these factors were key in the formation of miniSASS. Yet for all their importance as biomonitoring agents, the identification of macroinvertebrates is not easy, particularly to the untrained eye. Personal experience along with 46% of the respondents shows that the identification of macroinvertebrates is the most troublesome part of the miniSASS task. A possible solution could be the use of a bug dial (See Appendix 6) or a dichotomous key, as it expressly defines and highlights certain characteristics that are found on an organism in comparison to others (Gooderham & Tsyrlin, 2005). Sixty percent of the respondents agreed that this would simplify the identification of invertebrates.

**Western Cape scores**

On the miniSASS pamphlet each taxon is assigned a 'quality' score which is based on its susceptibility or resistance to pollution. The lowest scores are assigned to the taxa that are resistant and the highest scores to those that are susceptible to pollution (*Graham et al*, 2003). An issue which many people raised (which is unclear on the sheet) was the fact that some organisms in the Western Cape receive higher scores than those in the rest of the country. The reason for this is that several macroinvertebrate families only occur in the Western Cape region and are dependant on highly clean quality waters, thus their sensitivity score is very high (Tedder pers. comm. 2008).

**Community participation**

Due to the miniSASS's ease of use it has the potential to be used in every school, environmental centre and non-governmental organisation in South Africa as a monitoring cell. With such a significant spread, miniSASS could become a powerful 'red flag' indicator for the identification of aquatic pollution sources. The increased opportunity for communities to become involved and to use a biomonitoring tool that indicates the health of rivers is probably the most important aspect of the development of miniSASS. Broad based environmental awareness will only occur when the public is able to relate with and share in the experience. The involvement of the general public and the simplification of complex scientific tools will allow this. When the respondents were asked how more people could be encouraged to use miniSASS, the majority of the responses suggested including it as an exercise in the classroom and to advertise it through Eco-Schools programmes. This would raise the awareness of the youth to water quality at a young and influential age at which ideas are developed. This mindset would then hopefully continue to develop amongst all youth involved. Linking miniSASS to the national curriculum could be the perfect platform from which this concept

could be incepted. Subjects such as biology, agricultural science and geography were suggested as the most likely subjects under which miniSASS could be taught. It could also be linked to national days/weeks of celebration such as National Water Week which is held in the third week of March (EWT, 2007).

**Public participation**

The inclusion of the general public and the youth in national water quality monitoring could also be incorporated into the mandate of the Department of Water Affairs and Forestry (DWAF), who are the public trustee of the nation's water resources, and are responsible for all aspects of water resource management in South Africa. Annually, South Africa receives approximately 450 millimetres of rainfall, almost half of the world average of 860 mm/annum. Almost all of this water drains into rivers and dams, and it is thus imperative that we maintain these water courses (DEAT, 2006). DWAF has realised this and has consequently implemented a National Water Resource Strategy (NWRS) which focuses equally on the fitness of use of waters and aquatic ecosystems. The proposed strategies are broadly divided into 'resource' and 'source-directed' controls. Resource directed measures focus on the overall health or condition of an aquatic ecosystem and assesses its ecological status (DEAT, 2006). As a resource, miniSASS could operate as a perfect 'watchdog' to analyse the ecological status of rivers and to serve as an early warning system for decreased river health and increased pollution. The next possible step could be for the users of miniSASS, namely communities, environmental centres and schools, to correlate their results. Each Water Management Area (WMA), of which there are 19 in South Africa (DEAT, 2006) could set up a database (would need to be identical to allow for conformity) to which the general public could send their miniSASS results. These results could then be represented (possibly on a map such as those provided by Google Earth) in a way that could indicate river health at a national and local scale. For example, an individual could visit the WMA website and see that rivers and streams in urban areas are represented in red indicating that they are highly impacted and in poor condition. Rivers in blue on the other hand (usually found at the source or in conservation areas) would represent a healthy river with little to no impact. At present such an idea is in practice in the shape of the national State-of-Rivers (SoR) Report which forms part of the National River Health Programme. Multiple indicators are used to assess the health of certain major river systems and their tributaries, and to create an overall picture of river health in South Africa (DEAT, 2006) (See discussion on National initiatives and legislation). It would be a resource by the people for the people. In this way DWAF, the WMA's and communities could have a ready and constant source of information regarding river health. Ninety three percent of the respondents concurred with the idea of a database to which they could send their information and which was accessible to the general public.

**National initiatives and legislation**

The use of miniSASS in a database type concept could play an important role in the national River Health Programme (RHP). The RHP is a collaborative partnership between a number of governmental institutions, such as DWAF, DEAT and the WRC, which aims to ensure the health of aquatic ecosystems. The suite of tools that are used to analyse the health of aquatic ecosystems includes a habitat integrity index, a geomorphological index, the riparian vegetation index, SASS and a fish assemblage integrity index. The RHP supervises river health by providing information that is needed by both managers and the participating public, in decision making. Although the RHP is not specifically mandated by any South African act of parliament, its activities and outputs are strongly aligned with the legal requirements set forth by the National Water Act (NWA) (No. 36 of 1998). The NWA requires that the health of rivers be monitored and managed, and the RHP fulfils this role. River Health Programme results can also be used to support evidence of environmental degradation. If miniSASS could be incorporated into the national River Health Programme, it would not only support the NWA, but it could be used to achieve its principles of "managing aquatic ecosystems

through joint participation by all interested parties" (DEAT, 2006:p. 155). MiniSASS could be used not only to determine the health of aquatic ecosystems, but it could also be used to evaluate changes over time and indicate where environmental impacts are taking place.

**Translating the tool**

During the miniSASS workshop held in April the idea of translating miniSASS into other official languages was discussed. The main languages called for were Afrikaans, Zulu, Sotho and Xhosa. The problem with translation however lies in the fact that a translated tool does not necessarily mean a more commonly utilised tool. The time and money spent on translating miniSASS into other languages may not justify the cause. The national syllabus also encourages as many individuals as possible to learn English as it is a universal language. Having the tool in English may enhance this. In many instances the practitioner or teacher from whom the individual received the tool will also have a common knowledge of either English or the miniSASS tool itself and can thus translate important words and phrases. On the other hand the translation of the tool into other official languages may incorporate a wider audience and encourage those that are marginalised by language barriers to actively participate in the water monitoring process. Further investigations into the viability of translating the tool should be analysed.

**Learning outcomes**

Although the main aim of miniSASS is to monitor water quality health through the identification of macroinvertebrates, there are a number of secondary aims associated with it. The first of these is to teach those that are using it (generally school children and people that visit environmental centres) about scientific enquiry- individuals have to systematically and accurately follow instructions and collect data and then display the data. Secondly it teaches individuals about problem solving and design- if the necessary equipment is not available, it is possible for an individual to design and create their own. In some instances, where this is not possible, individuals can simply apply their minds and look under stones and rocks and identify the organisms that are present. Thirdly, miniSASS can be used to teach practical field work lessons that are hands on, and show the bigger environmental picture, for example aquatic indicator species and biodiversity. MiniSASS is also an important educational tool which can be used to link ideas such as sustainability, conservation, and human impacts on their environment and the consequential knock-on effects, to the idea of water quality management. Water quality and miniSASS are an integrative topic and can be used in a whole suite of applications.

**Qualitative response**

A number of concerns and suggestions were raised as to the layout of the miniSASS tool. Respondents said that the text is too small, that there is too much of it, that instructions are not clear and that the introduction should possibly be shortened. Some respondents further suggested that the methodology should perhaps be in point form for easier reading (and less space) and for a clearer understanding. Other suggestions included; drawing flow diagrams for the methodology as this would aid the illiterate in using the miniSASS tool and making it more accessible to a greater portion of the general public.

Another issue that was raised by the respondents was the fact that miniSASS does not provide information as to what can be concluded from the results, or how they contribute to national water quality monitoring. Thus, it was suggested that perhaps a brief discussion or a table about what can and cannot be concluded from the results and what follow up actions one should take, should be added to the miniSASS as a discussion or conclusion section. This could also play a part in making the general public feel as if they were contributing to water quality in some way, that their participation was appreciated and that their involvement was recognised and applied.

As has been mentioned, a way in which this could be achieved is by creating a database to which the public could send their results. A key concern about the database is that if the general public are adding the data themselves it may lead to confusion and skewed results. Therefore it would be important for the database to be screened and managed by a professional or someone with some water quality and computer skills. A second suggestion as to how this could be mitigated is if the issue of sampling were to be explicitly defined. If it was clearly stated on miniSASS where to sample, how to sample and for how long to sample the data would have conformity allowing the general public themselves to input the data as it would not need to be screened. Schools and environmental centres could receive a password and individuals would have to register with the site and in this way it would be hoped that data would not be tampered with. The possibility of creating an online, downloadable version of miniSASS is also an important suggestion. This website could provide links to other environmental websites such as WESSA, Adopt-a-River and even the national River Healthy Programme. This could galvanise those that visit it into further caring not only for the aquatic environment, but the environment as a whole. Yet such a system could be seen to be benefiting only those 'better off' schools that have electronic resources. A possible solution could be for somebody (most likely an individual working for that specific WMA) to physically go and collect the miniSASS data every half year or so, and in the process to give a feedback talk as to what results have been gathered and possibly what mitigation measures have been put into place.

Another issue that needs to be rectified is that of scoring. It has been noted that many individuals try to collect frequency data rather than presence data and in this way become confused as to how the scoring process should be undertaken, and what the end result of miniSASS represents. A clear, concise description of what steps need to be taken to calculate the score should be mentioned on the miniSASS pamphlet.

The identification of macroinvertebrates poses perhaps the biggest problem to the miniSASS user, particularly in differentiating between mayflies, damselflies and stoneflies. Compounded by this is the fact that the organisms can be found in many different stages in their life cycle and in a number of different shades of colours. As such, suggestions were put forth to create the miniSASS with photographs or colour drawings. The problem herein lies with the fact that colour pamphlets are very expensive to produce (even in bulk), and that the identification of invertebrates in colour can lead to a 20% increase in identification error (Graham pers. comm. 2008). A possible solution to implementing colour or photographs could be to explain key features on the organism that can be used to identify it. For example a stonefly's forelegs are directly attached to the first segment of the thorax and the eyes are found on the side of its head. A second solution could simply be to suggest other identification manuals, such as the Share-Net "Hands on: Pond and Stream Life" series.

A further 'add on' to the miniSASS pamphlet may be the addition of facts surrounding the analyses of river quality and health. Due to the fact that the identification of macroinvertebrates is just one method of identifying river health it has been suggested that other water quality testers, such as pH sticks and turbidity testers (See Appendix 7) be incorporate into miniSASS. The concern here is the fact that miniSASS is a simple and basic assessment of river health and thus the introduction of other testers would make it cumbersome and complex and not aimed at the layman and general public. A note on various other water quality testers could be posted on the miniSASS pamphlet and the miniSASS website (if it were to be developed) to allow for a wider knowledge of water analyses.

At the miniSASS workshop it was proposed that the idea of developing a more simplified juniorSASS be investigated. This would be targetted at primary and pre-primary school children who have difficulties with miniSASS identification and scoring. The viability of this was assessed, and the general response from the respondents indicated that this was not necessary. MiniSASS is already a simplified, condensed version of SASS5 and any further simplification would render it unscientific and user specific. As one of the secondary aims of miniSASS is to teach scientific enquiry and

understanding, it is to be expected that children do not necessarily understand the concepts straight away-this is part of the scientific learning process. Also, in many instances, a facilitator should be present who can define and help clarify any misunderstanding.

This also raises the issue of safety: seventy-nine percent of the respondents said that river safety was an issue. River safety refers to numerous factors including the presence of dangerous animals, polluted water, a lack of swimming ability etc. Therefore it is vital that a note regarding river safety in terms of protective gear, adult supervision, health risks and safety be posted on the miniSASS pamphlet as there is none at present.

MiniSASS has the potential to become a tool used on an international scale in southern Africa, as well as in numerous different spheres in South Africa, but support for it needs to be established or else its full potential will not be realised. One way of doing this could be to incorporate it into the national syllabus. This would cement its success. However this process will take some time. In the mean time it could be advertised at teacher's forums, in conservation newsletters (such as those produced by WESSA), in magazines such as African Wildlife and perhaps on other water quality pamphlets. This will ensure that the tool becomes a success.

## Recommendations

As has been recorded there are limitations and problems that have been identified with the miniSASS tool. Not all of these are associated with the tool itself, but rather with its future success, for example ways in which miniSASS can be marketed so that the general public are encouraged to use it. According to Morris and Stilwell (2003) choosing appropriate content for a pamphlet includes a few key factors namely brevity, pictures/diagrams, colour, legibility of text, and quantity of text. It is these factors that have been used to guide suggestions for the miniSASS tool. The first (and possibly most important) is the use of a dichotomous key, or the present identification system. If a dichotomous key is opted for then, due to space limitations, it will be necessary to have an identification/field manual and a separate information pamphlet. Due to the extra space on the information pamphlet additional information regarding miniSASS, its history, its possible use in national water quality management, connection to national water legislation, etc. could be included.

If a miniSASS database were to be established then the site would also be added to the information pamphlet as well as other water quality sites, books, organisations, etc. The pamphlet could form part of the facilitation process for users, so it would contain the introduction and methodology as to how a miniSASS test should be conducted. The scoring sheet could be added to the information pamphlet so as to allow for more space on the identification manual. Individuals could mark on the identification manual what species had been identified and then tally up scores (on the information pamphlet) back at school/camp. The field guide would simply contain diagrams of the macroinvertebrates, and possibly a few guides on what characteristics may be helpful in identifying the organism.

Alternatively, if creating two separate sheets is not viable, then a second suggestion would be to keep the current miniSASS form. However, the layout would have to be redesigned to be more exciting and user friendly. Ways in which this could be achieved could be by reducing the introduction, i.e. the amount of text on the front cover, and putting the methodology in point form. Diagrams on how to make one's own equipment could also be added to the front cover and could play a part in attracting the public's eye to the miniSASS tool. A lot of the text on the inside page can potentially be removed as it does not all refer to macroinvertebrate identification. This could free up some space so that the last macroinvertebrate class (true flies) can be added to the inside page. Thus all the Invertebrate classes will be on a single page. The last page could then contain instruction (in point form) on how to tally the scores, and the score sheet could be added below this. This would eliminate the need for a separate score sheet paper as there is currently.

A note on river safety would have to be added to the pamphlet whether it be the collective pamphlet or the two separate sheets. For an example of the proposed changes and designs please see Appendix 8.

## Conclusion

"There is a practical need to set out existing water quality monitors that are accessible to non-specialists" (New, 1998:p. 2) and the miniSASS tool has the potential to fill this role. Its importance lies in the fact that it can be used by schools, environmental education centres and communities alike, on both a national and international scale. Thus, through a participatory process which included a workshop, analysing the experiences of miniSASS users and through expert input, it was determined that the remodelling of the tool would be the best option to enhance its success. Possible recommendations for its improvement have been determined and put forth. It is hoped that the redesigning of the tool will make it easier to use and attractive to the general public, making it a key tool in national water monitoring and conservation.

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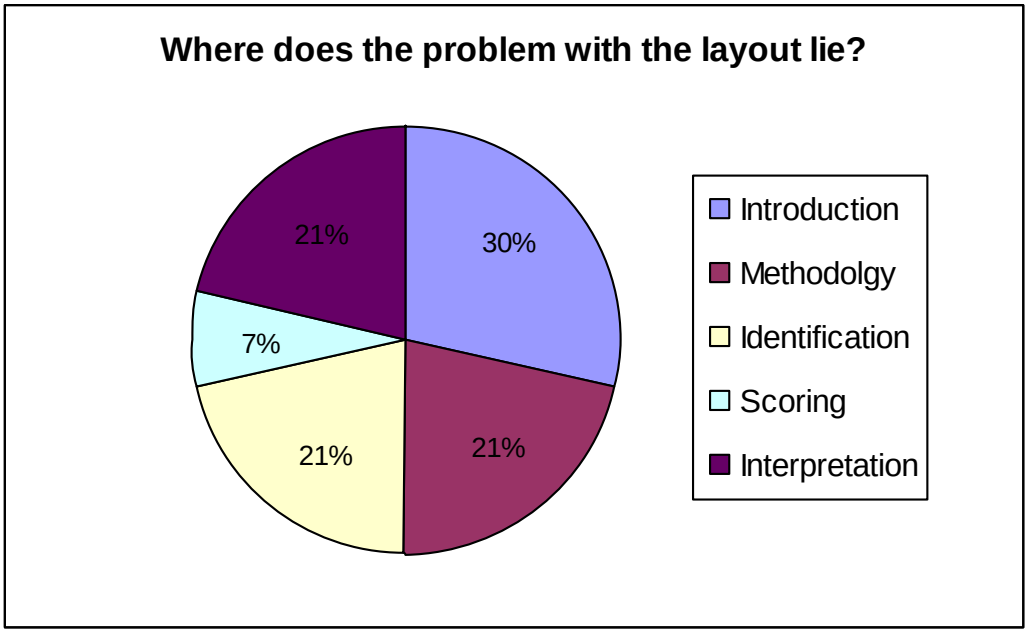
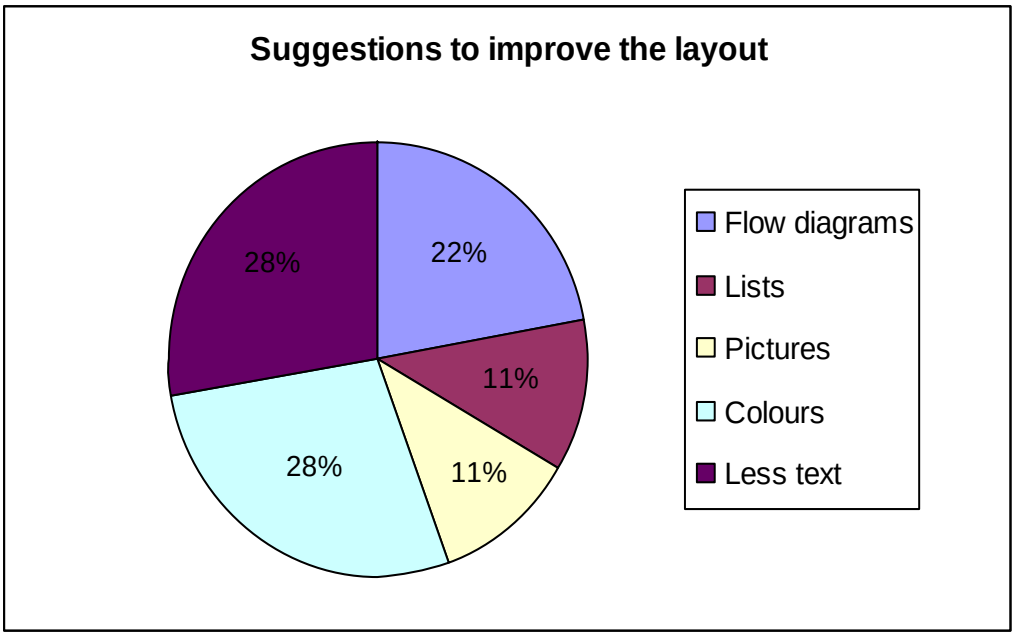
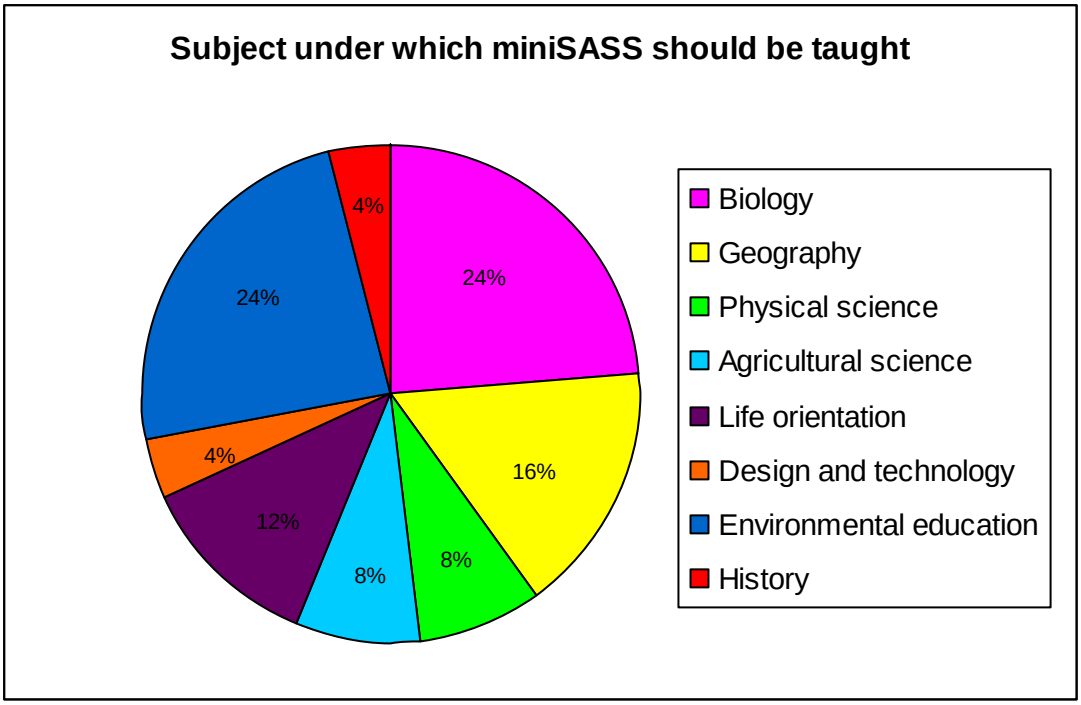
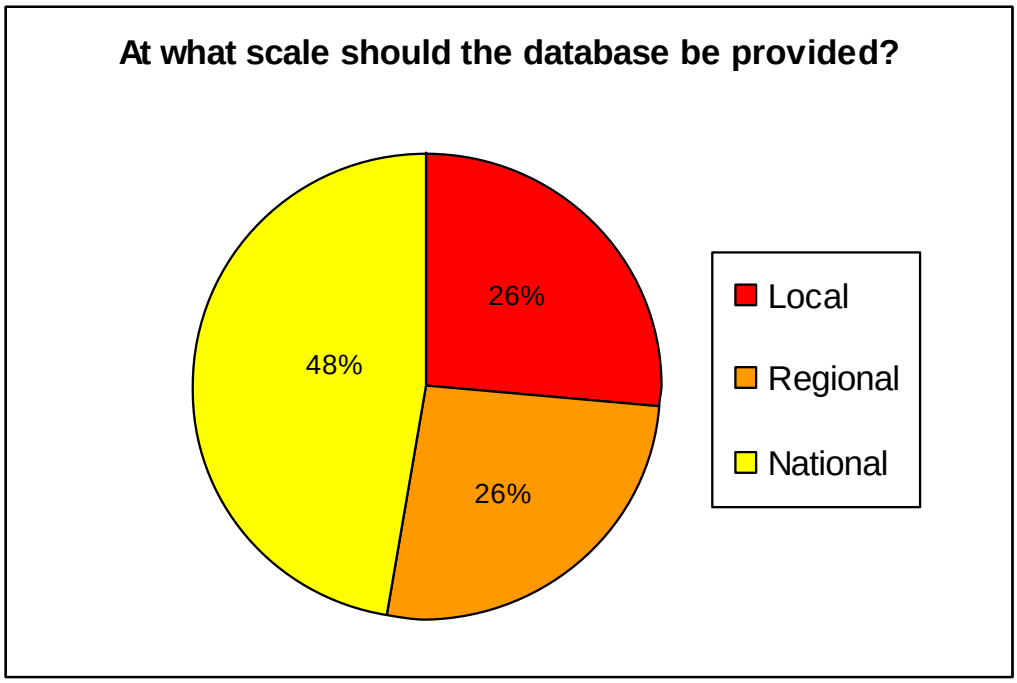
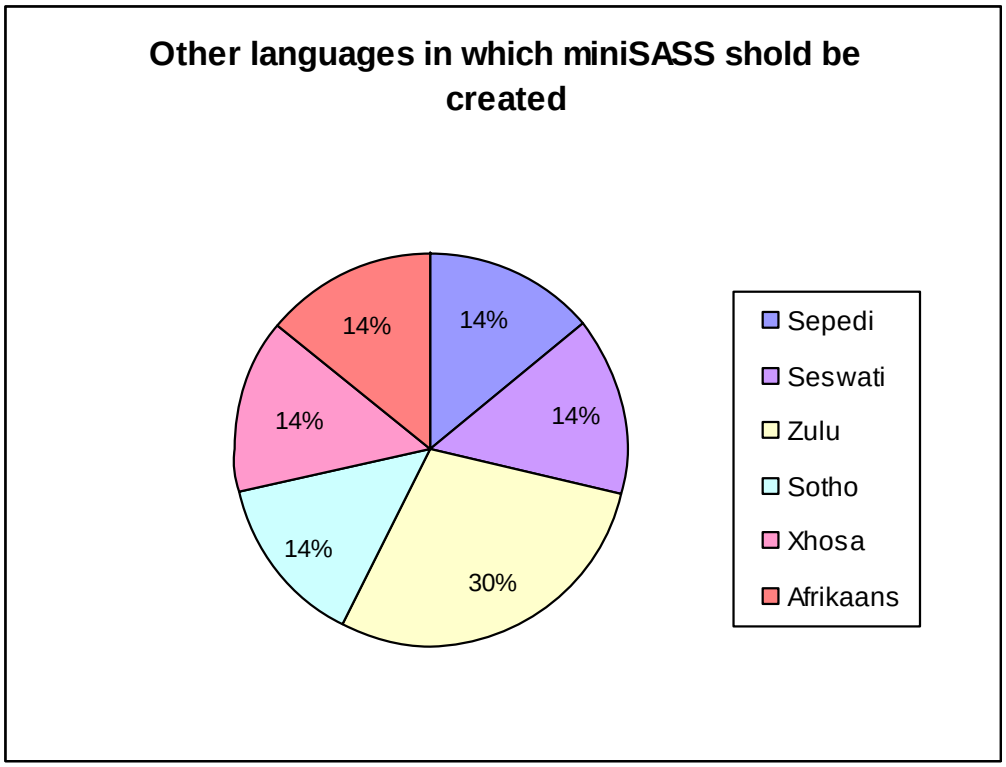
**Appendix 4: Outstanding results**

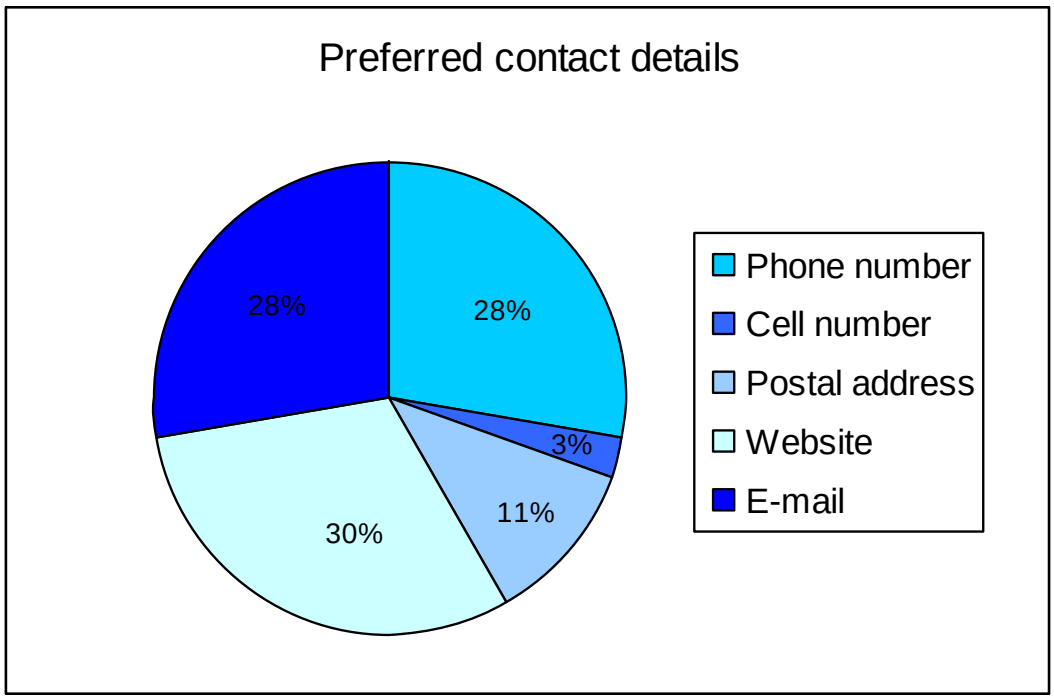


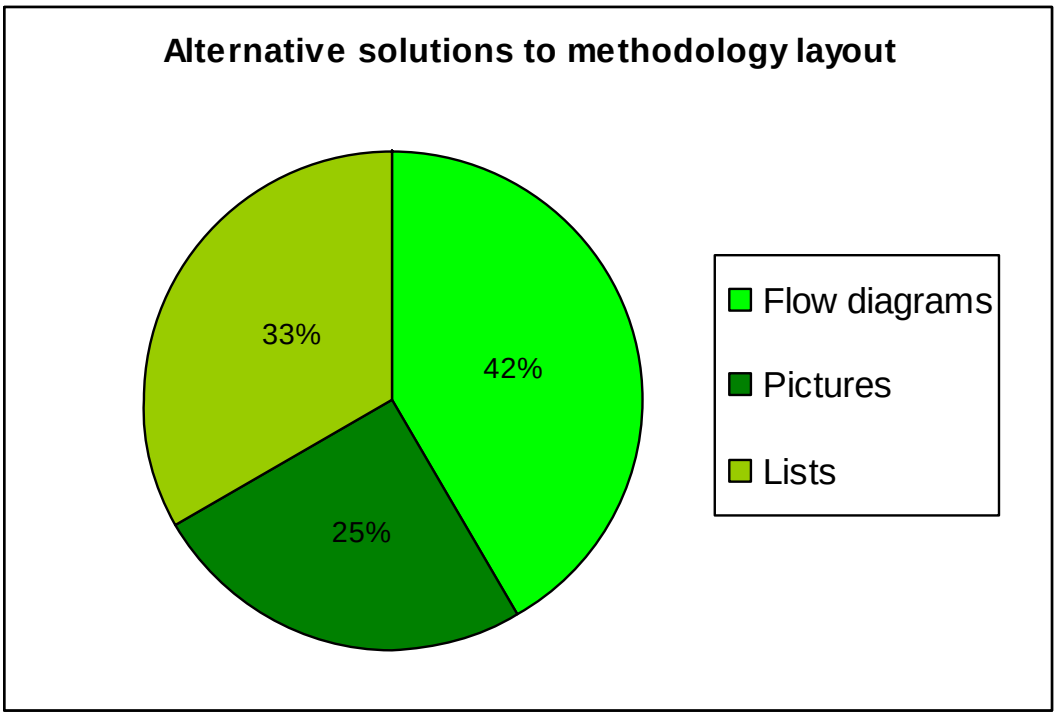




Subject under which miniSASS should be taught
24%
16%
8%
8%
12%
4%
24%
4%
Biology
Geography
Physical science
Agricultural science
Life orientation
Design and technology
Environmental education
History


At what scale should the database be provided?
26%
26%
48%
Local
Regional
National


Other languages in which miniSASS shold be created
14%
14%
14%
14%
14%
30%
Sepedi
Seswati
Zulu
Sotho
Xhosa
Afrikaans


Preferred contact details
28%
28%
3%
11%
30%
Phone number
Cell number
Postal address
Website
E-mail


Alternative solutions to methodology layout
33%
42%
25%
Flow diagrams
Pictures
Lists

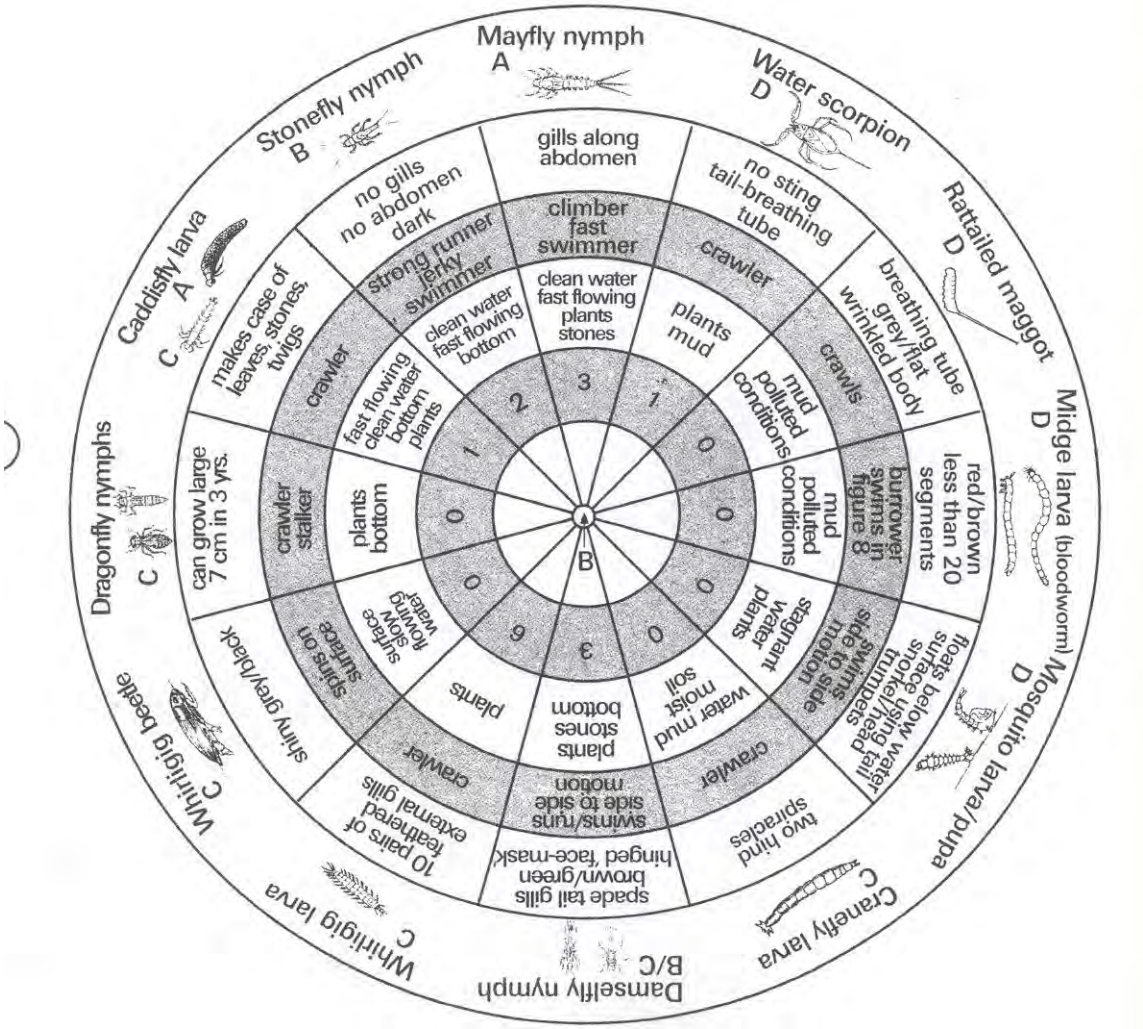
**Appendix 5: Raw bi-plot data**

| Groups | Sensitivity score (Sample 1) | Sensitivity score (Sample 2) | Sensitivity score (Sample 3) | Sensitivity score (Sample 4) | Sensitivity score (Sample 5) |
|---|---|---|---|---|---|
| Flat worms | 0 | 0 | 0 | 0 | 0 |
| Worms | 1 | 1 | 1 | 0 | 1 |
| Leeches | 1 | 1 | 1 | 1 | 1 |
| Crabs or shrimps | 1 | 1 | 0 | 0 | 0 |
| Stoneflies | 0 | 0 | 0 | 0 | 0 |
| Minnow mayflies | 1 | 1 | 1 | 1 | 1 |
| Other mayflies | 0 | 0 | 0 | 0 | 0 |
| Damselflies | 1 | 1 | 0 | 1 | 1 |
| Dragonflies | 0 | 0 | 0 | 1 | 1 |
| Bugs or beetles | 1 | 1 | 1 | 0 | 0 |
| Caddisflies | 0 | 0 | 0 | 0 | 0 |
| True flies | 1 | 1 | 1 | 0 | 0 |
| Snails | 1 | 1 | 1 | 1 | 1 |
| | | | | | |
| Average score | 4 | 4 | 3.7 | 4.4 | 4 |

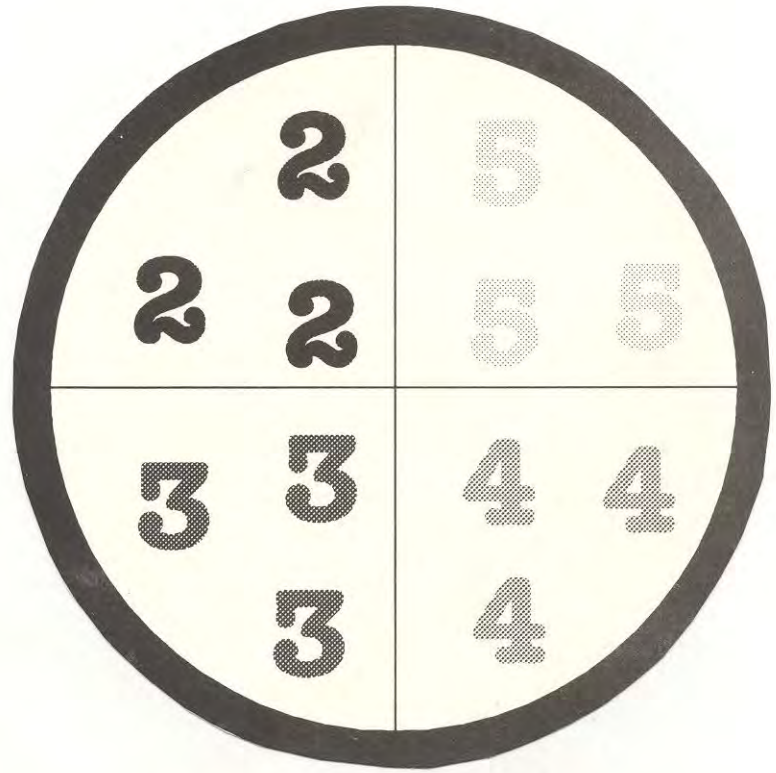
**0= absence**

**1= presence**

**Appendix 6: WESSA bugdial**



**Appendix 7: Turbidity tester**



## Appendix II: miniSASS version 2 – resource materials

**Version 2.0 November 2011**

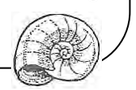
miniSASS can be used to monitor the health of a river and measure the general quality of the water in that river. It uses the composition of macroinvertebrates (small animals) living in rivers and is based on the sensitivity of the various animals to water quality. (note: miniSASS does NOT measure the contamination of the water by bacteria and viruses and thus does not determine if the river water is fit to drink).

## Equipment list

- net
- white container / tray / ice-cream box
- pencil
- magnifying glass (optional)
- shoes/gumboots
- Hand wash / soap

**How to make your own net**

Take any piece of wire, for example an old clothes hanger, and bend it into the shape of a net. Then tie the netting (which can be any porous material) to the wire with a piece of string. And you have a net!



## Method

The best sites are those with rocks in moving water. Not all sites have rocks (**rocky type** rivers), but may be largely sandy (**sandy type** rivers).

1. Whilst holding a small net in the current, **disturb** the stones, vegetation, sand etc. with your feet or hands.
2. You can also lift stones out of the current and **pick** insects off gently with your fingers or forceps.
3. Do this for about **5 minutes** whilst ranging across the river to **different habitats** (biotopes).
4. Rinse the net and turn the contents into a plastic tray and **identify** each group using the identification guide (see insert: you could start with the dichotomous key and then use the identification guide for more information).
5. **Mark** the identified insects off on the identification guide.
6. Fill in the site information and **Add up** the sensitivity scores to determine the average score (see scoring sheet on back page).
7. Remember to **WASH** your hands when done!

## History of the miniSASS tool

South Africa has been a world leader in biomonitoring techniques using macroinvertebrates. The most successful of these is the South African Scoring System version5 (SASS5). miniSASS is based on SASS and also uses the presence of macroinvertebrates to indicate the "health of a river". Where SASS5 contains over 90 different macroinvertebrate classes, miniSASS only has 13 different classes, allowing for simpler identification and understanding. miniSASS has been found to provide similar indications of "river health" status as the more comprehensive SASS5 assessment, thereby providing a good means of generating useful biomonitoring data. The original miniSASS (version 1) was developed/based on approximately 2000 SASS4 data records, whilst this updated miniSASS (version 2) is based on over 6000 SASS5 records. This makes miniSASS v2 more robust as a useful water quality monitoring tool & more widely applicable in Southern Africa.

**Macroinvertebrates**

**What are they?**

Macroinvertebrates are animals that have no backbone and can be seen with the naked eye.

**Why they're used for biomonitoring?**

- Different macroinvertebrates have different sensitivities to pollution. The higher their score, the more sensitive they are.
- They are generally easy to collect and identify.
- They are relatively sedentary which allows the source of pollution to be detected.
- They integrate the water quality conditions at a site, providing an overall measure of the "health" of a river.
- They can provide a picture of the historical water quality at a site.

## What is the importance of water quality monitoring and management in South Africa?

Fresh water is essential for most life on earth. It is also used in all spheres of human life, namely agriculture, industry, biodiversity conservation, sanitation and hydration. However due to the amount of rainfall that South Africa receives, it is classified as a water stressed country. This means that if we do not monitor, manage and conserve our current water resources, we will be placing them and the population under tremendous stress in future!

## DICHOTOMOUS KEY

**Start !**

Shell → **Snails**

No shell → Legs

Legs → Clearly defined legs

Clearly defined legs → 4 plus pairs of legs

4 plus pairs of legs → Pincer-like front legs

Pincer-like front legs → Yes → **Crabs**

Pincer-like front legs → No → **Shrimp**

Clearly defined legs → 3 pairs of legs

3 pairs of legs → Wings → Hard, leathery front wings (NB. Wings may be folded)

Hard, leathery front wings (NB. Wings may be folded) → **Bugs and beetle**

**Beetle larvae**

Hard, leathery front wings (NB. Wings may be folded) → Portable shelter/ covering (made of sand, leaves, sticks) → **Cased caddisflies**

3 pairs of legs → No wings → No Tail → Bulging eyes → **Dragonflies**

Short, stubby legs (prolegs) → **True flies**

No legs → Unsegmented body → **Flatworms**

No legs → Segmented body → Suckers on both ends → **Leeches**

Segmented body → Long, thin body → **Worms**

3 pairs of legs → No wings → Tail → Tufted tail → **Uncased caddisflies**

Tail → Elongated tail → Generally 3 tails → Feathery or plate-like gills on abdomen → **Other mayflies**

Feathery or plate-like gills on abdomen → Humped back, fish like way of swimming → **Minnow mayflies**

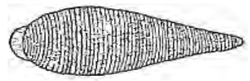
Generally 3 tails → No feathery gills on abdomen → Long body → **Damselflies**

Elongated tail → 2 tails → **Stoneflies**

## 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

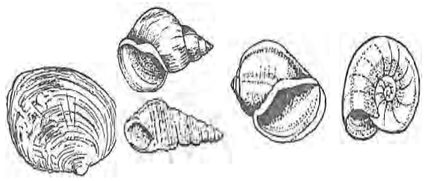


Leeches are segmented organisms that have very flexible bodies. When moving they expand to become long and thin, and then contract to become short and stubby. They have suckers on both ends of the body that are used for feeding and locomotion. Leeches are variable in colour, from grey, to red-brown and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

## Worms

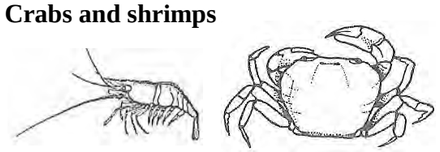
Worms are long and segmented and have a cylindrical shape much like small earth worms. Their colouring is usually pink to brown. They are usually seen writhing around in debris digesting the substrate they fed on.

## Snails



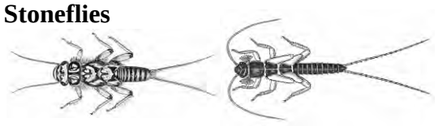
Snails are molluscs with hard shells that vary in size, shape and colour. Habitats vary, with some snails such as limpets clinging to rocks, whereas clams and muscles are found in sand. The more common snails move over stones and vegetation. Some snails are host to bilharzia, a serious health hazard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

## Crabs and shrimps



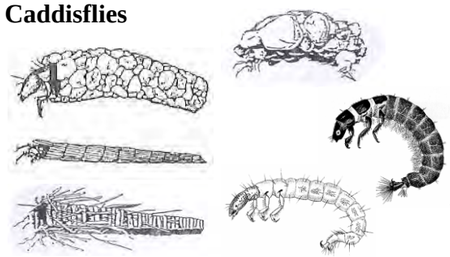
Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs and eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the chance.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

## Stoneflies



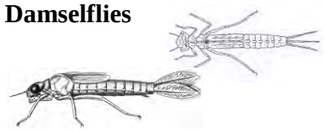
The nymphs of adult stone flies usually have two long tails and three pairs of legs each having two claws at the tip. A characteristic feature of stonefly nymphs are the tufts of gills on the side of the body as well as gills between the two tails. Wing pads on the thorax are often dark and obvious. 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



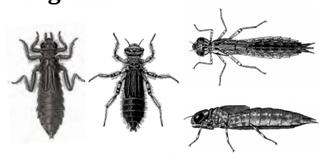
The aquatic larvae of adult caddisflies have a hard head with three pairs of legs which are attached to an elongated, soft body. Finger-like gills on the abdomen and anal appendages can be seen with the naked eye. Some caddisflies construct portable shelters/cases from sand grains, bits of vegetation 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



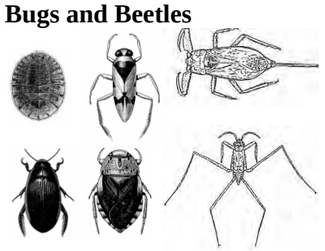
Damselflies have elongated bodies with generally three broad tails/gills on the tip of the abdomen. Damselflies are carnivorous and have a 'mask' over the lower part of the face which hinges out to reveal a pair of pincers with which they catch their prey. They are often to be found in vegetation growing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

## Dragonflies



Dragonflies 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.

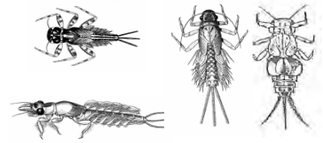
## Mayflies

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

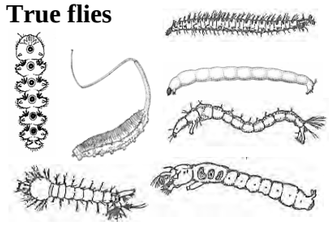
These mayflies have a narrow head and a small, slender, but not flattened body. They have leaf shaped gills on both sides of the abdomen and two but more commonly three tails, depending on the species.

## 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.

As the general public, we can play a part in making a difference to managing freshwater resources in a community. miniSASS has the potential to be a powerful 'red flag' indicator for the identification of aquatic pollution sources. By using miniSASS we can actively take an interest and management in the health of freshwater bodies in our community.

Your interest and knowledge can be enhanced by adopting a local river in your community and monitoring it over time, identifying sources of pollution and taking local action to make a difference. You could also encourage more members of the community to take positive action towards monitoring and conserving water.

**Download copies of miniSASS**

www.minisass.org

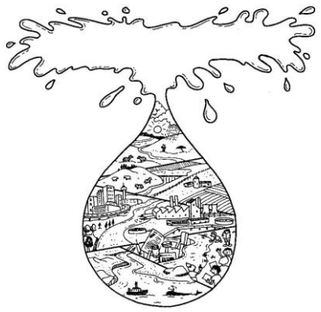
www.groundtruth.co.za

Additional resources

www.wrc.org.za

www.wessa.org.za

www.dwa.gov.za



Send your results to results@minisass.org
to contribute to a developing picture of river quality in South Africa.
For queries or comments email info@minisass.org
miniSASS is also available from Share-Net
www.sharenet.org.za PO Box 394, Howick, 3290. Tel (033) 3303931

**River safety**: take special care in polluted waters. Beware of dangerous animals (crocs/hippos!) and fast flowing waters. Wear protective gear when necessary and wash your hands regularly with soap and clean water wherever possible!!

**Key words for further reading/resources:**
macroinvertebrates, benthic, water quality, conservation, biodiversity, water quality, river health, aquatic pollution.

## Glossary

**Biomonitoring:** the monitoring of biodiversity using biological organisms
**Biodiversity:** diversity within species, between species and of ecosystems
**Conservation**: the maintenance of environmental quality and functioning
**Ecosystem:** a complete community of living organisms and the nonliving materials of their surroundings.
**Sedentary:** inactive, motionless, not moving

| SITE INFORMATION TABLE | | |
|---|---|---|
| Date (dd/mm/yr): | | |
| Collectors name: | | |
| River name: | | |
| Site description: | | |
| GPS co-ordinate: | S | E |
| Comments / notes | | |

Co-ordinates as lat/long (e.g. 29°30'25" S / 30°45'10" E) **OR** as decimal degrees (e.g. 29.50694°S/30.75277°E)

**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 | 2 |
| Leeches | 2 |
| Crabs or shrimps | 6 |
| Stoneflies | 17 |
| Minnow mayflies | 5 |
| Other mayflies | 11 |
| Damselflies | 4 |
| Dragonflies | 6 |
| Bugs or beetles | 5 |
| Caddisflies (cased & uncased) | 9 |
| True flies | 2 |
| Snails | 4 |
| **TOTAL SCORE** | |
| **NUMBER OF GROUPS** | |
| **AVERAGE SCORE** | |
| Average Score = Total Score ÷ 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 above 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/critically modified (VERY POOR condition) | < 4.3 | < 5.1 |

## Appendix III: miniSASS version 2 – National Curriculum educational resource materials

# SUGGESTED

# LESSON PLANS

# GRADE 5

# ACTIVITY ONE: WATER IN THE HOME

**During this MATHEMATICS activity, learners look at the quantity of water used in their homes over a 24-hour period.**

**ACTIVITY:**

1. Take your class for a walk around the school. Show the learners where water meters can normally be found (on the verge, near the driveway, etc). Show the learners how to read a water meter. The pictures below show the two most common types of water meters used in South Africa.

Digital meter

Dial meter

2. Take the learners back to the classroom after they have seen the water meter and are able to read it correctly. Ask each learner to design a simple table, which will be used to record the amount of water used in their home. *An example of this table can be found below. This is not for the learners to use, but should give you, the teacher, an idea of what a record sheet should look like.*

| | | | | |
|---|---|---|---|---|
| **Start Date** | | | | 20/01/2009 |
| **End Date** | | | | 21/01/2009 |
| **Meter reading at start** | | | | 5022 |
| **Meter reading at end** | | | | 5022.22 |
| | | | | |
| **Activity** | **Time** | **Person** | **Amount of water used in litres (*l*)** | **Amount of water used in kilolitres (*kl*)** |
| Bathing | 7:05pm | Myself | 200 | 0.2 |
| Washing dishes | 8:00pm | Mother | 20 | 0.02 |
| **TOTAL WATER USED** | | | 220 | 0.22 |

Ask the learners to keep a record of water use in their homes for a single day, although it can be done for a longer period. The learners must convert their readings from litres (*l*) to kilolitres (*kl*). *One kilolitre = 1000 litres.* Learners should take readings before and after the major uses of water in their homes to get an idea of how much water each activity uses. The water meter reading must be entered into the table on the day that the project starts and ends.

3. Learners should total the amounts of water they have recorded in their tables. This total will be the amount of water that they have recorded being used in their house over a single day.

4. Get learners to subtract the meter reading at the start of this activity, from the meter reading at the end of this activity. This will be the amount of water that has been used over a day, which the learners can use to check their totals against.

## AS A CLASS, DISCUSS:

1. Activities that use the most water in the home.
2. Ideas to lower the amount of water used in the home.

**Criteria to assess learners during this mathematics lesson**

| **Criteria** | **Exceeded requirements of the Learning Outcome** | **Satisfied requirements of the Learning Outcome** | **Partially satisfied the requirements of the Learning Outcome** | **Not satisfied requirements of the Learning Outcome** |
|---|---|---|---|---|
| The learner made a simple record sheet to gather information about water usage in their homes. | | | | |
| The learner used their record sheet to gather information about water usage in their homes. | | | | |
| The learner correctly converted the S.I. units in the required calculations. | | | | |

# ACTIVITY TWO: RAIN AND SOUTH AFRICA

**During this SOCIAL SCIENCES: GEOGRAPHY activity, learners will look at rainfall distribution in South Africa, and indicate the major users of water in these regions.**

**READ THE FOLLOWING TO YOUR CLASS:**
The human body consists of approximately 75% water and the longest that we are able to survive without water is 3 to 4 days. Water is one of the most valuable resources that we have on this planet. The surface of the earth is covered with water. However, most of this is salty and undrinkable. Only 2.5% of this water is fresh and of this, 99% is found in icebergs or underground lakes.

In South Africa, the main source of water is rainfall, which falls into river catchments, and is then stored in dams, and eventually flows into the oceans. The distribution of rainfall over South Africa is very uneven with the eastern portion receiving more than 850mm per year, while the extreme western region receives less than 100mm per year. For this reason, it is important that the catchments within this country are conserved, as they play a vital role in supplying clean water throughout the year. Catchments in good condition act like sponges, in that they slowly release clean water, and are still able to do so during a mild drought.

However, because of all the air pollution, the climate is changing. A basic definition of climate would be the weather in some location that has been averaged over a long period of time. This means that there may be more rainfall over some parts of South Africa, and less rainfall in other parts. People are very worried about this because they do not know if there will be enough rain in future to grow food, or fill dams. People think that there may be more rain over the eastern side of South Africa, and less over the western half of South Africa. This climate change may be slowed down if water and air pollution can be stopped or at least reduced. Unfortunately there has been too much damage done to stop this change altogether.

**WHAT TO DO:**

1. Hand out a copy of Worksheet 1 on page 5 to each learner.

2. Ask learners to colour in the rainfall map*. Use dark blue where there is lots of rain, and red where there is little or no rain.

3. Indicate what farmers grow in each province on your map.

** You will need to explain the rainfall pattern across South Africa, using the map and key on page 4.*

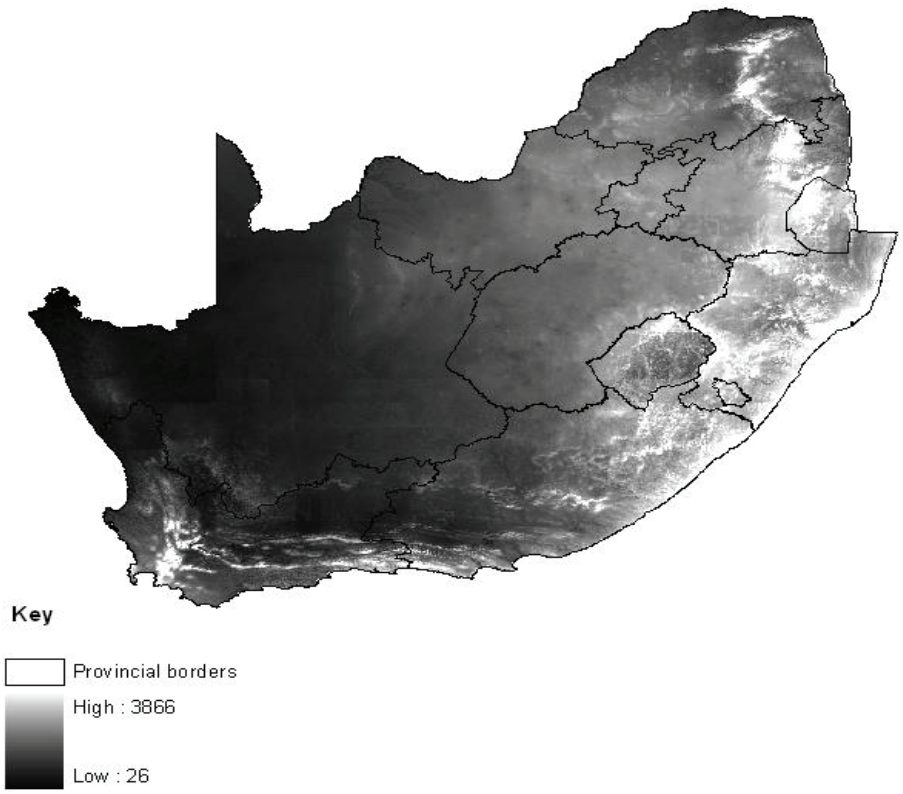
**QUESTIONS TO ASK THE CLASS:**

1. If you were a sugar cane farmer, where would you want to live to ensure that your sugar cane would be successful?
2. Which province in South Africa has the most rain?
3. What type of plants are found in the dry regions?
4. What type of plants are found in the wet regions?
5. What do you think are the main crops grown in each province?
6. Have you heard of the words “climate change”? If so, what is your understanding of these words?
7. What would happen to farmers if there was a long drought?

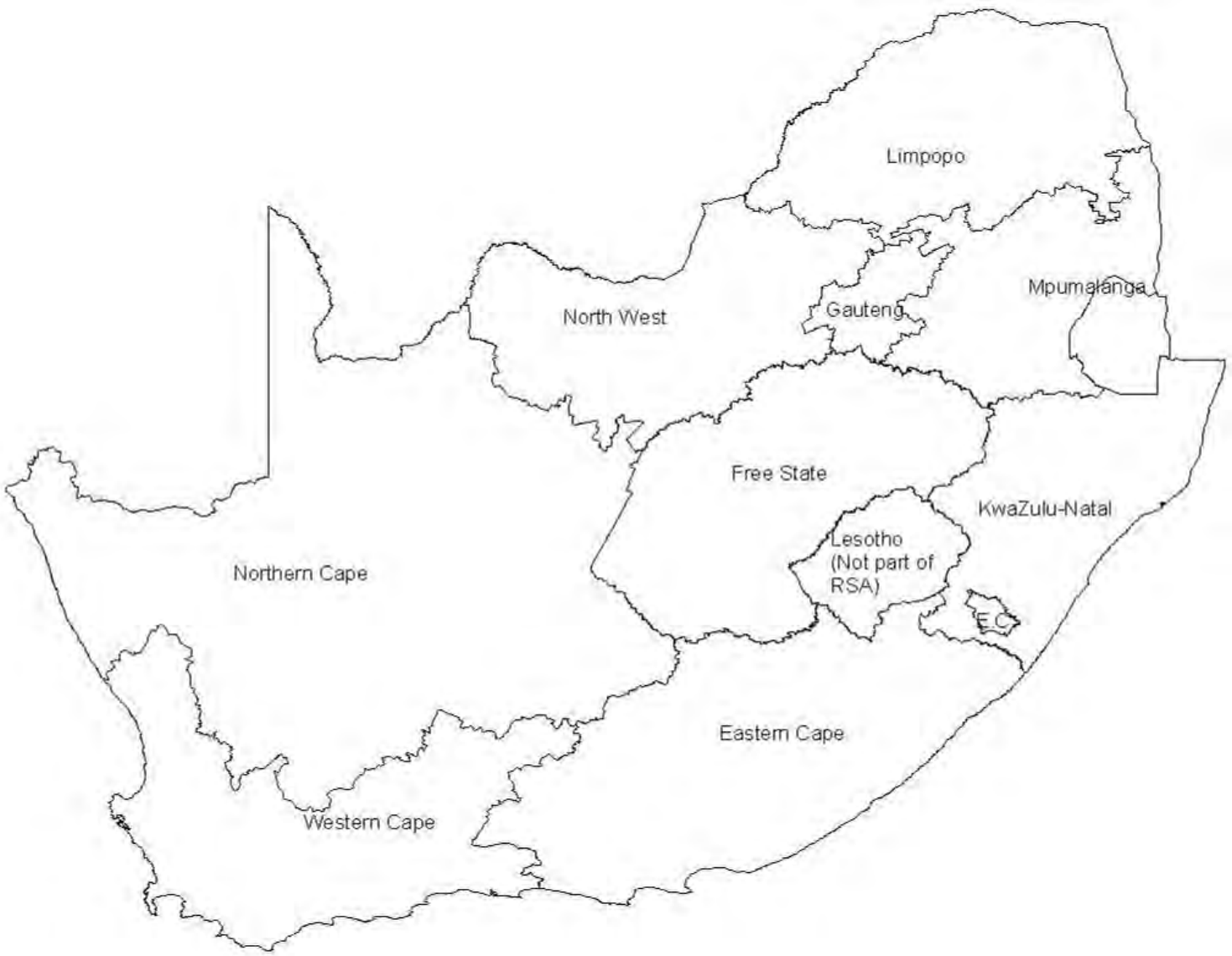
*For question 3 of “What to do” and questions 1-6 of “Questions to ask the class”, it may be useful to have available a collection of library books on agriculture, farming and gardening in South Africa.*

*Those areas that are black receive very little rainfall while those areas that are white, receive much higher levels of rainfall.*

## MAP OF RAINFALL IN SOUTH AFRICA



**WORKSHEET 1**


Limpopo
North West
Gauteng
Mpumalanga
Free State
KwaZulu-Natal
Lesotho
(Not part of
RSA)
EC
Northern Cape
Eastern Cape
Western Cape

**Criteria to assess learners during this social sciences: geography lesson**

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied the requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| Learner was able to indicate the types of plants found in wet and dry regions. | | | | |
| Learner knew where sugar cane would grow successfully. | | | | |
| Learner grasped the concept of" climate change" and its possible implications | | | | |
| Learner had an idea of what drought was, and what the implications of this phenomenon were. | | | | |

# ACTIVITY THREE: MAKE A SIMPLE WATER FILTER

**During this TECHNOLOGY activity, learners will make a simple water filter.**

**Read the following to the learners:**
Water companies, like Umgeni Water in Pietermaritzburg, KwaZulu-Natal, pump water from dams or rivers, and then it is processed so that it is safe to drink. Filters form part of the cleaning process, and are used to remove fine particles from the water. Sand filters have been used for many years to remove dirt, and are still used in the filtration process today. Many swimming pool filter systems have sand filter systems. However, if the water is discoloured or has a foul (unpleasant) taste, then sand filters will not be able to remove the agents (chemicals, pollution) responsible for this. This is why chlorine and other chemicals are added to water.

## Let's make our own water filter

Each learner will need:

1. 1 two-litre plastic cooldrink bottle
2. A cloth plug
3. Pre-washed sand
4. Pre-washed gravel
5. Scissors

**WHAT TO DO:**

1. Cut the cooldrink bottle in two, about half-way up the bottle.

2. Place the top half in the bottom half so that it forms a funnel, that will drain the water into the bottom half.

3. Push the cloth plug into the end of the funnel. This will prevent sand and gravel running into the water collection container.

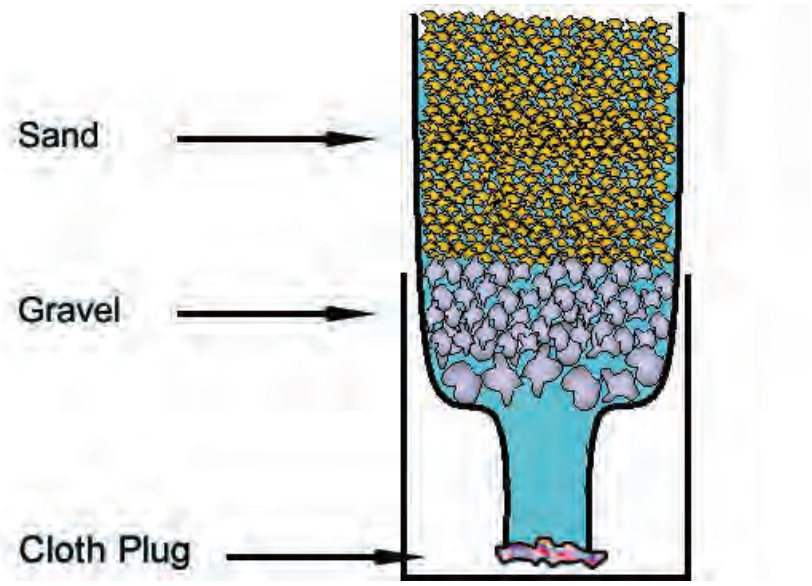
4. Place a layer of gravel in the funnel, over the cloth plug. It should be approximately 2cm thick to form an effective filter. *Layer thickness may vary according to the thoroughness of filtration required.*

5. Pour a layer of sand over the gravel. Ensure that the two do not mix too much, otherwise sand may come through the filter, and make the water dirtier than you started off with. This layer should be about 6 or 7cm thick to form an effective filter. *Again, layer thickness may vary.*

6. To test this filter, a variety of materials should be available to mix with the water. Use substances such as sand or dirt to test the effectiveness of the filter in the removal of solids. To show that the filter is unable to remove soluble substances, food colouring may be used.

*Teachers, ensure that learners **do not waste** the materials that they have been given. The learners should receive one plastic bottle and the correct amount of sand and gravel that is required for the gravel filter. They should also only receive one material plug.*

**What your sand filter should look like**




**ASK THE CLASS:**

1. Did their filters work well?

2. Could they have improved them? How?

3. What should they do to the water to make it safe for drinking after they have filtered it? *Adding chlorine to small amounts of water will make it toxic, so this is not an option. This water should be boiled to kill any germs.*

4. Why is it important not to waste the resources you are given?

## Criteria to assess learners during this technology lesson

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied the requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| Learner worked neatly and safely, ensuring minimum waste of material. | | | | |
| Learner placed correct amount of gravel and sand in the funnel. | | | | |
| Learner was able to evaluate the operation of their sand filter. | | | | |

# ACTIVITY FOUR: WATER IS WONDERFUL!

**During these LANGUAGES activities learners are introduced to the aquatic ecosystem. A word search is followed by a reading activity and comprehension.**

**WORD SEARCH:**
In the block below, biotic (living organisms) water words are hidden. See how many you can find. There is a glossary at the bottom of this page. Use it to find out what these words mean.

| A | M | J | G | F | F | E | R | T | H | J | K | H | Y | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D | F | E | R | T | Y | H | F | S | E | H | N | G | R | E |
| S | V | E | R | T | E | B | R | A | T | E | Y | F | S | A |
| F | A | R | E | W | W | J | K | I | H | R | M | J | S | N |
| M | F | L | H | R | S | N | H | R | E | O | P | R | E | T |
| J | I | U | G | E | Q | A | E | E | R | N | H | T | D | M |
| N | S | H | R | A | E | E | S | T | F | G | H | T | G | R |
| H | H | R | E | W | E | C | N | C | H | E | R | Y | E | J |
| N | H | R | E | D | F | A | B | A | H | R | H | F | N | P |
| N | I | N | V | E | R | T | E | B | R | A | T | E | M | B |
| V | B | G | G | F | E | S | D | F | E | R | Y | I | H | G |
| V | F | M | O | L | L | U | S | C | C | D | R | X | F | E |
| V | G | D | R | R | E | R | E | D | N | H | N | M | H | G |
| V | F | R | F | H | Y | C | N | H | S | F | E | Y | H | J |
| N | S | D | A | V | F | R | E | D | S | A | D | C | F | E |

Look carefully!
The words could be horizontal, vertical, diagonal, backwards or forwards.

- Algae
- Invertebrate
- Crustacean
- Bacteria
- Mollus
- Nymph
- Vertebrate
- Fish
- Heron
- Frog
- Sedge
- Shrimp

**GLOSSARY**

**Algae** – Simple plants, nearly all aquatic.
**Invertebrate** – An animal that does not have a spinal cord e.g. an insect.
**Crustacean** – Most aquatic animals that have a shell e.g. crabs, shrimps.
**Bacteria** – Micro-organisms (very small animals).
**Mollusc** – Invertebrate animals with soft unsegmented bodies, which normally have a shell, e.g. snails and clams
**Nymph** – A stage in the life cycle of certain animals e.g. dragonfly nymphs *(before they become dragonflies).*
**Vertebrate** – An animal that has a spinal cord e.g. fish.
**Heron** – Wading birds normally found in wetlands or along the edges of rivers.
**Sedge** – A coarse grasslike plant growing on wet ground.
**Shrimp** – A small shellfish with a long tail and a pair of pincers.

# LIFE AT THE SURFACE

The surface of a river or pond divides two very different worlds. Beneath the surface the water is cool and wet, and while it provides support it is hard to swim through. It can also be murky and poor in life-giving oxygen. Above the surface the air can be hot and dry, and it provides little body support. However, it is often clear and always rich in oxygen. Most animals live their whole lives either under or above the water surface. However, a few species can move freely between the two, and for some the water surface is a good place to live.

## Feathered floaters

Many birds swim and float about on the water and dive for food beneath the surface. Some, like coots, eat water-weeds, but ducks prefer water insects, and darters and pelicans feed on fish. Most water birds keep dry by having oily feathers that repel water. The feathers of darters and cormorants get wet when they dive, which is why you often see them spreading their wings out to dry in the sun.

## The water walkers

One of the unusual properties of water is that it clings strongly to itself. Its surface is like a tough, elastic skin on which small animals can walk. The best known are the long-legged pond skaters. These insects have tiny fans of waxy hairs on their feet to stop them sinking. The middle pair of legs is used to 'row' across the surface as the pond skater hunts for floating insects.

## Frogs have it all

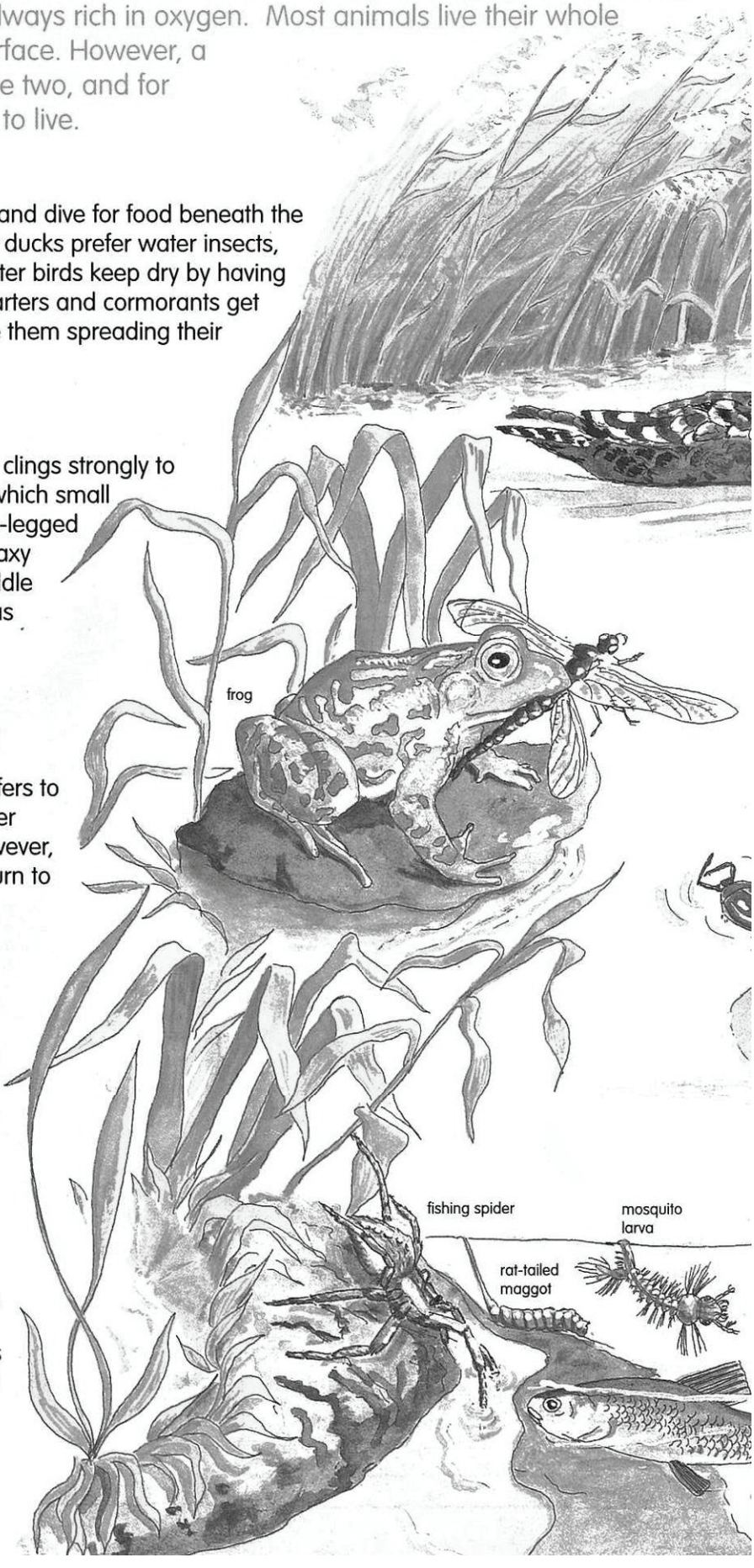
Frogs and toads belong to a group called the amphibians. This word means 'both life' and refers to the fact that most tadpoles live and feed in water while the adult frogs live and feed on land. However, because frogs have a soft skin they have to return to water to wet their skins occasionally.

## Double vision beetles

The whirlygig beetle lives half in and half out of the water as it swims madly about hunting for fallen insects. The large eyes are divided – the top half looks up into the air, and the bottom half down underwater. If disturbed, it dives through the surface skin, carrying a bubble of air from which to breathe.

## Spiders that fish

Most spiders make webs to catch flying insects, but fishing spiders can walk on the water surface. They 'angle' for small fish and tadpoles by dabbling the tips of their feet in the water as bait. When prey arrives, they quickly reach down to snatch it out of the water.



## The surface restaurant

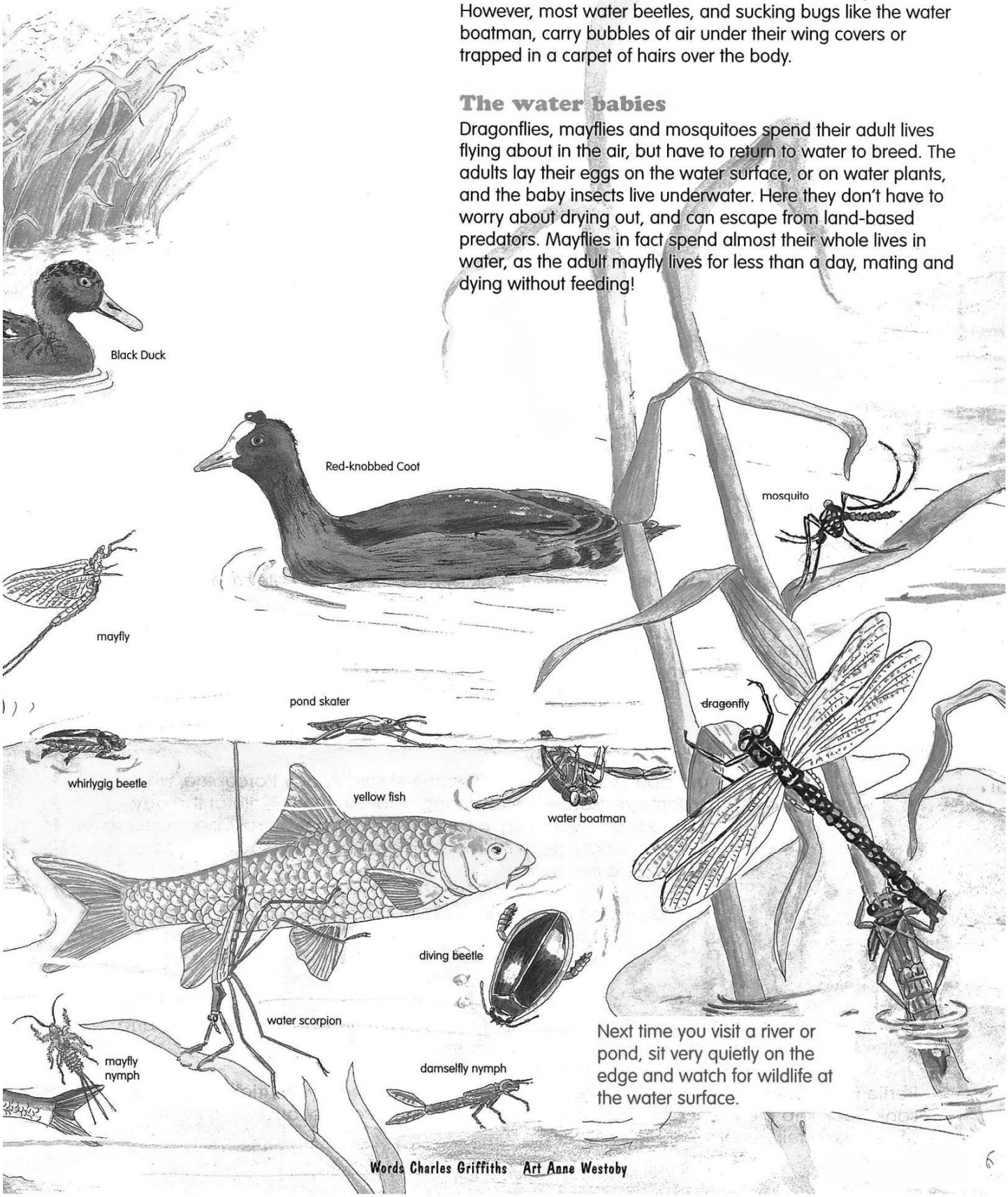
The sticky water surface traps many small insects that accidentally fall in. They make a rich source of food for fish that lie in wait for tasty morsels to float by overhead.

## Snorkels and air bubbles

Many underwater insects need air to breathe. Some, like the water scorpion (a sucking bug) and the rat-tailed maggot (fly larva), have long tubes or 'snorkels' that reach to the surface so that they can remain underwater while breathing air. However, most water beetles, and sucking bugs like the water boatman, carry bubbles of air under their wing covers or trapped in a carpet of hairs over the body.

## The water babies

Dragonflies, mayflies and mosquitoes spend their adult lives flying about in the air, but have to return to water to breed. The adults lay their eggs on the water surface, or on water plants, and the baby insects live underwater. Here they don't have to worry about drying out, and can escape from land-based predators. Mayflies in fact spend almost their whole lives in water, as the adult mayfly lives for less than a day, mating and dying without feeding!




Next time you visit a river or pond, sit very quietly on the edge and watch for wildlife at the water surface.

Words Charles Griffiths Art Anne Westoby

*"Life at the Surface" has been reproduced from WESSA's EnviroKids magazine with permission.*

The following questions are based on the article "**Life at the Surface**" on pages 10 and 11. Provide learners with copies of the article to read, before working through the following questions.

1. How does a water boatman breathe while under the water?

2. Although the dragonfly spends most of its time flying in the air, why do they need to be around water?

3. The whirlygig beetle is easy to identify in water as it moves and whirls very quickly on the surface of a pond or river. The eyes of the beetle are very special. Why is this so?

4. Fishing spiders don't make webs to catch their prey. How do they find their food?

5. The rat-tailed maggot lives in the oozing mud and slime on the bottom of ponds and rivers. There is not much oxygen in these conditions so how do they breathe?

6. How do you think a diving beetle would breathe under water?
   *Hint: to answer this question, think about its name.*

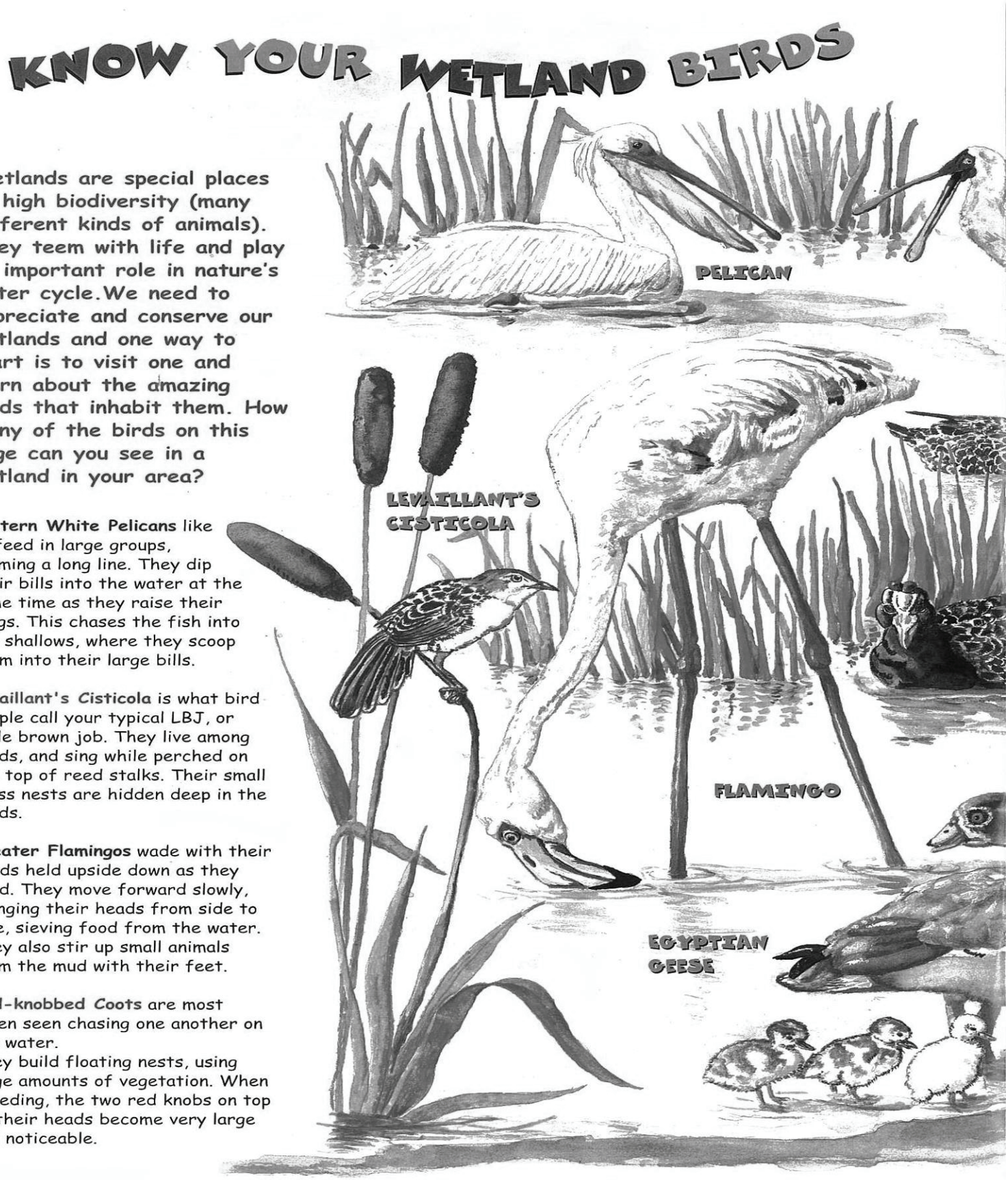
7. To swim under water, what do human beings have to do to be able to breathe?

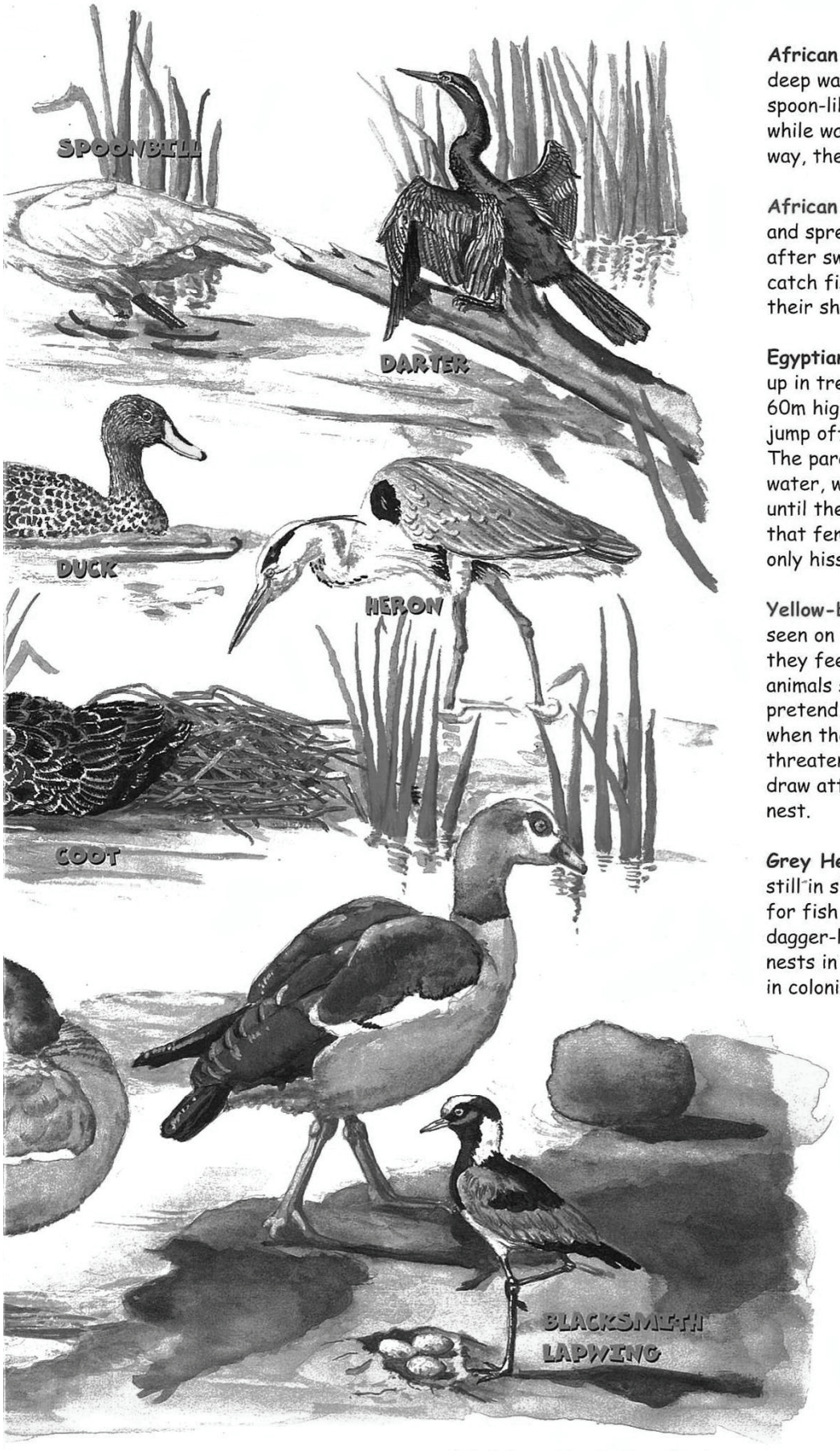
**Criteria to assess learners during this languages lesson**

| **Criteria** | **Exceeded requirements of the Learning Outcome** | **Satisfied requirements of the Learning Outcome** | **Partially satisfied the requirements of the Learning Outcome** | **Not satisfied requirements of the Learning Outcome** |
|---|---|---|---|---|
| Learner is able to find all the words in the cross puzzle unassisted. | | | | |
| Learner is able to answer questions about the natural system correctly. | | | | |
| Learner understands the relationships in the article and what the article is about. | | | | |

# ACTIVITY FIVE: KNOW YOUR WETLANDS BIRDS

**During this LANGUAGES activity learners will be introduced to wetland birds, through a reading exercise and comprehension, followed by a creative exercise.**






**African Spoonbills** feed in knee-deep water, sweeping their spoon-like bills from side to side while walking forward. In this way, they 'feel' for their food.

**African Darters** perch on trees and spread their wings to dry after swimming underwater to catch fish. They impale them on their sharp, pointy beaks.

**Egyptian Geese** often nest high up in trees or on cliffs – up to 60m high! The goslings have to jump off and drop to the ground. The parents then walk them to water, where they care for them until they grow up. Did you know that females honk while males only hiss?

**Yellow-billed Ducks** are often seen on dams and rivers, where they feed on water plants and animals such as insects. They pretend to have a broken wing when their nests or ducklings are threatened – they do this to draw attention away from the nest.

**Grey Herons** often stand very still in shallow water, watching for fish to spear with their dagger-like bills. They build large nests in trees and live together in colonies called heronries.

**Blacksmith Lapwings** (or Plovers) are easily recognised by their 'clink, clink, clink' call, which sounds like a blacksmith's hammer on an anvil. They nest on the ground and lay camouflaged eggs that are not easy to spot. When disturbed, they fly around calling loudly in an attempt to chase you away.

Words Sally van Zyl  Art Anne Westoby

*"Know Your Wetland Birds" has been reproduced from WESSA's EnviroKids magazine with permission.*

## READING AND COMPREHENSION SKILLS

1. What does the word “biodiversity” mean?

2. Describe how a flamingo collects its food.

3. In which species of bird does the male hiss?

4. Why has the Blacksmith Lapwing been given this name? What is a blacksmith?

5. The story gives examples of how different birds use their beaks to catch food. Give two examples of how they do this.

6. What is a LBJ and give an example of a bird which could be called a LBJ?

## CREATIVE WORK

Make a poster to show people how important wetlands are and why we need to conserve them and the animals that live in them. Use magazines and books from your school or community library.

*Remember not to put too much information on the poster. Concentrate on one or two main points.*

**Criteria to assess learners during this languages lesson**

| **Criteria** | **Exceeded requirements of the Learning Outcome** | **Satisfied requirements of the Learning Outcome** | **Partially satisfied the requirements of the Learning Outcome** | **Not satisfied requirements of the Learning Outcome** |
|---|---|---|---|---|
| Learner understands the vocabulary used in the text. | | | | |
| Learner is able to answer the questions correctly without any significant assistance. | | | | |
| Posters made are creative, and focus on one or two main points. | | | | |

# SUGGESTED

# LESSON PLANS

# GRADE 7

# ACTIVITY ONE: RIVER WATER QUALITY – WHO IS REALLY RESPONSIBLE?

**In this LANGUAGES activity, learners research and find out more about river water quality in their area. A newspaper article forms the focus point for a general class debate around river health.**

**ACTIVITY:**
Ask the learners:

1. Have you seen or taken part in a debate?
2. What was it about?
3. Where did it take place?
4. Who was taking part in the debate? *Prompt: Politicians, general public, members of a group or organisation.*

**READ THE FOLLOWING TO YOUR CLASS:**
A debate is an organised clash of good ideas. Each side uses worthwhile evidence to promote their viewpoint and to challenge the "flawed" evidence advanced by the other side. Debating is a formal intellectual contest and it can take place in many different ways. However, a good debate is like a tennis match where each side, following the rules set down, bats ideas back and forth to defeat the other team. Debaters have to persuade the judges that their argument is best and that they should win. Emotions often run high in debates and it can be very exciting!

**What makes a good debater?**
Debaters challenge ideas, they do not attack each other. Like other sports, fair play is critical. Regular debaters will be transferred to play on the other side later in their careers, so it does not pay to be too emotionally tied. A debater is a spokesperson during a particular time for or against a motion and is not a fanatic for a cause.

**How do we conduct a debate?**
There are different ways to hold debates. Generally, you need a Chairman, Proposer, Opposer, Proposer and Opposer's Seconders and a Timekeeper.

**ACTIVITY:**
Hand out pages 2 and 3 to the learners. After reading ‘Debate Rules (page 2)’, let the learners try to work out the correct sequence that a debate should follow on page 3. *Answers on page 4.*

**DEBATE RULES**

1. **Chairman:** Controls the debate; is neutral; a type of judge.
2. **Proposer:** Speaks for the motion; a type of lawyer arguing for the motion.
3. **Opposer:** Speaks against the motion; a type of lawyer arguing against the motion.
4. **Proposer's Seconder:** Second speaker for the motion; helps proposer.
5. **Opposer's Seconder:** Second speaker against the motion; helps opposer.

Motion: The topic being debated; the wording is important.

**How to proceed in a debate:**

**A)** No. 1 Reads the motion
No. 2 Speaks **for** the motion
No. 3 Speaks **against** the motion
No. 4 Speaks **for** the motion
No. 5 Speaks **against** the motion

**B)** Then after numbers 2-5 have spoken:

I. Chairman opens debate to the floor (rest of the class).

II. Individuals ask questions of speakers 2-5 only when chairman says they can speak.

III. Individual stands up and starts by saying, "Mr/Ms Chairman."

IV. Individuals speak carefully. No insulting names, must say things like, "a previous speaker" or "the proposer's seconder says…"

V. Keep the debate impersonal, attack ideas **not** people.

VI. Individuals can make statements or ask speakers 2-5 to explain something. Speakers 2-5 answer.

**C)**

I. After the class has nothing else to say or ask, or if time is up, the Chairman closes the debate to the floor (the class).

II. Chairman asks the **Proposer** to briefly sum up his/her main idea.

III. Chairman asks the **Opposer** to briefly sum up his/her main idea.

IV. Chairman then reads the motion to the class (to make sure they understand it.)

**D)** The Chairman stands up and asks:

I. "Those **for** the motion to put up their hands." (chairman counts and writes down the number).

II. "Those **against** the motion to put up their hands." (chairman counts and writes down the number).

III. "Those who are neutral/abstaining (can't make up their minds) put up their hands." (chairperson counts and writes down the number).

IV. Chairman then says whether the motion is **carried** (proposer wins) or **defeated** (opposer wins) by saying "I declare this motion – reads motion – carried or defeated."

**Remember:**

- Abstainers, no matter how numerous, can never win.
- Chairman has casting vote in the event of a tie.
- Vote on the ideas heard in the room, not on what you know from elsewhere.

*Source: http://www.learnquebec.ca/export/sites/learn/en/content/curriculum/social_sciences/documents/debate_rules.doc*

**See if you can un-muddle the steps in this debate by putting a number next to each sentence…**

An opposer sums up their group's main argument.

The first proposer presents the arguments for the motion.

The Chairman announces the result of the vote.

One of the proposers presents their arguments for the motion.

Everyone votes (apart from the Chairman).

The debate is chaired by the Chairman, who reads out the motion.

This side-to-side motion continues until everyone has had their say. You can only speak ONCE during the debate.

A proposer sums up their group's main argument.

The first opposer presents the arguments against the motion.

An opposer presents their arguments against the motion.

The Chairman re-reads the motion.

**Check your answers against the correct order:**

1. The debate is chaired by the Chairman, who reads out the motion.
2. The first proposer presents the arguments for the motion.
3. The first opposer presents the arguments against the motion.
4. One of the proposers presents their arguments for the motion.
5. An opposer presents their arguments against the motion.
6. This side-to-side motion continues until everyone has had their say.
7. You can only speak ONCE during the debate.
8. A proposer sums up their group's main argument.
9. An opposer sums up their group's main argument.
10. The Chairman re-reads the motion.
11. Everyone votes (apart from the Chairman).
12. The Chairman announces the result of the vote.

**CLASS ACTIVITY:**
Photocopy *The Witness* newspaper article *'A river in crisis'* (on pages 5 and 6) – this is a shortened version of the story - and hand a copy to each learner in your class to read.

**ASK THE LEARNERS THE FOLLOWING QUESTIONS:**

1. Why is this newspaper article called *'A river in crisis'*?
2. Have you seen any rivers in crisis in your area? What did you see?
3. What are the many uses of rivers?
4. Who are all the people who make use of rivers? For what uses/purposes?
5. What do you think is meant by " … Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself."

# A river in crisis

15 Feb 2008

*Julia Denny-Dimitriou*

"Duzi Canoe Marathon 2008 has come and gone. The organisation was great, ... records were broken and with Michael Mbanjwa winning his first Duzi and Martin Dreyer his seventh, history was made. Pity about the bugs ..." So writes Dave Still, chairman of DUCT (Duzi-uMngeni Conservation Trust), on the organisation's website.

The "bugs" in the Umsunduzi river not only made local and national news, they also made many of the paddlers in the canoe marathon sick with "Duzi guts" — diarrhoea and/or vomiting. DUCT conducted a survey among competitors which found that 45% of the Duzi 2008 participants became ill. The Duzi organising committee threatened to move the start of the race, and, if necessary, to cancel it. It also expressed concern that international competitors might not return to participate in future events.

"Duzi guts", however, is not a new phenomenon. According to Still, a paddler himself, canoeists have experienced it for 30 to 40 years and the water quality during the 2006 marathon was even worse. On the first day of that race, the E.coli readings were over 50 000 counts per 100 ml (a "tolerable" or "moderately low" count is 10 000 to 20 000).

The issue of bugs in the river is much broader and more serious than the future of the canoe marathon. The state of rivers is a vital indicator of the health of the catchment area around them and how the land is being used. "If a river is stressed, it means that the whole ecological system is stressed," says Ezemvelo KZN Wildlife aquatic scientist Nick Rivers-Moore.

The Witness has carried allegations that local people are dying of sewage-borne diseases such as hepatitis and severe diarrhoea (The Witness, February 1). The Witness contacted the KwaZulu-Natal Department of Health about the effect that E.coli levels in the river have on the health of communities that live on its banks. However, the department had not responded at the time of going to press.

*Why has this happened?*

If the river has been polluted enough to make paddlers sick for years, we have to ask why this has been allowed to happen and what must be done to clean up the Duzi.

According to Still, river pollution has been allowed to deteriorate to its current levels because the health of rivers is not an issue of public concern. On the DUCT website he writes: "When the lights go out, everyone notices. If your water supply failed you would certainly have something to say about it. A failure of the sewerage system, on the other hand, can go on for years or even decades without anyone caring, because who knows or cares if the river is chronically polluted?"

Rivers-Moore believes the state of local rivers is also the result of "the gap between science and management". "Scientists may know why things happen and what to do about them, but their scientific knowledge needs to be mainstreamed — made available to people in management and put into practice."

Judging by the process required to gather information about this issue, it seems as though no single government authority or organisation is responsible for river management. It falls between two bodies: the Department of Land Affairs and the Department of Water Affairs and Forestry (DWAF). The process

becomes even more complex when it gets down to the local level.

*What causes the pollution?*

The Duzi suffers three main types of pollution: solid waste, faecal waste or sewage, and industrial pollution. E.coli from faecal pollution are the bugs that make Duzi paddlers ill. Regular water quality testing shows that pollution enters the Duzi inside the city's municipal boundaries where an estimated 600 000 people live. The section of the river affected stretches from Edendale below Henley Dam to beyond the Darvill waste water plant on New England Road.

According to river scientist and environmental consultant Dr Mark Graham, faecal pollution is the biggest and most complex problem, and is tied in with solid waste. "Storm water drains and sewers become blocked because communities use them as rubbish dumps. Many sewers are broken and need repair. Damaged pipes can obviously let raw sewage out and storm water in. Unscrupulous property developers and poorly informed members of the public also illegally discharge storm water into the sewers rather than storm-water drains. Pressure build-up can make sewers overflow, sometimes discharging raw sewage into the rivers and streams.

"The situation is made worse during storms, which is what happened during the Duzi marathon. Under extreme conditions the Darvill sewage works cannot cope with the large volumes of storm water that find their way into the sewers. The plant is unable to put this mix of storm and waste water through the system and clean it properly. Instead, it is forced to treat the sewage with large quantities of chlorine and pump it directly into the river. What happens when there is a storm is like expecting the R103 to carry the traffic that uses the N3 during peak holiday season."

*What needs to be done?*

Sorting out the faecal and solid waste problems requires action across a broad front, with the Msunduzi Municipality taking the lead role. The major requirements are:

• provision of solid waste and sewage services and infrastructure supported by consumer education;

• monitoring, replacement, repair and maintenance of sewers;

• replacement, repair and maintenance of equipment in the municipal water and sanitation department;

• more skilled staff; and

• inspection of new property developments and enforcement of municipal building by-laws on storm and waste water management.

Dealing with the industrial pollution requires a similar effort by the municipality to monitor and control industries that illegally discharge industrial waste into the river and DWAF to prosecute offenders.

*Is it too late?*

Dr Graham still believes that it is not too late to clean up the rivers and that the pollution is reversible. However, he says, "...we should be realistic. While we can hope for better [water] quality [for the Duzi] next year, the work will take several years."

Rivers-Moore also says that it will take more than scientific and management intervention to reverse river pollution. "We need people to change their behaviour and values. The long-term safety of rivers is not secure until people recognise the truth of Chief Seattle's words that 'all things are connected like the blood that unites us all. Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself.' "

*Source: The Witness*

# IT'S TIME TO DEBATE!!!

**CLASS ACTIVITY:**

1. Divide the class into two groups.

2. Give them the following debate topic.

***River water quality is the sole responsibility of local municipalities/local governments.***

3. One group needs to prepare their debate agreeing with the topic (the proposers); the other group needs to argue against it (the opposers).

4. Using the attached three enviro facts sheets (*Water, Sustainable Development* and *Pollution*) as an introduction to water quality, learners need to find out as much as they can about this topic. If you have a well-resourced library (in your school or community), make use of it; use the Internet; search for newspaper articles or magazines; see if there are any environmental films or videos on water quality or any other sources of information that could be useful. *(Learners need to keep a record of where they found their sources and what these sources were – this will help you, the teacher, when it comes to the assessment of this lesson).* Some of the learners may have parents or relatives that work either for the sanitation/water departments of local municipalities, water boards or provincial or regional Departments of Water Affairs and Forestry (DWAF) so they will be able to interview these people. Encourage the learners to make use of as many varied sources and methods of locating information as possible.

5. When the groups are ready and well prepared, you need to select six learners to take various roles:
    - Chairman. This person chairs the debate but cannot take part or vote (unless there is a tie)
    - First proposer to speak
    - First opposer to speak
    - Proposer's seconder
    - Opposer's seconder
    - Timekeeper

Encourage all other learners to participate from the floor, reminding them that each one can only speak once. They will also need to be ready to vote at the end of the debate.

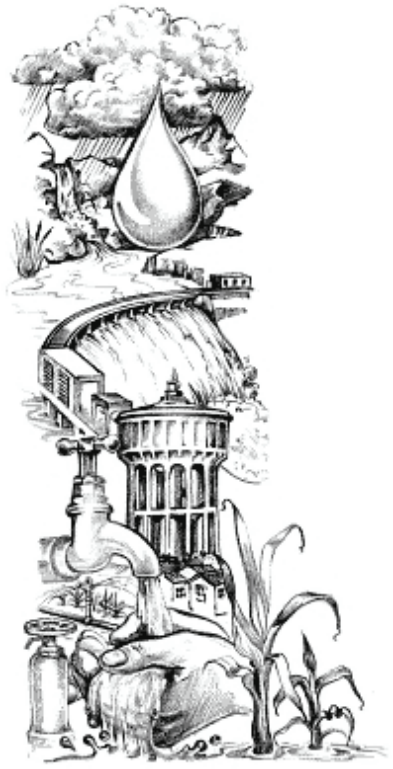
Hold the debate according to the formal order and rules.

**Ask the learners:**

1. What are the advantages of debating?
2. What are the disadvantages of debating?
3. Describe the strengths of a good debater. *Prompt: persuasive, confident, calm.*
4. What skills could one develop through the debating process?

*Source: http://news.bbc.co.uk/cbbcnews/hi/newsid_4530000/newsid_4537100/4537177.stm*

## Enviro Fact 1: Water



South Africa is extraordinarily rich in natural resources - except for water. Water is a vital but scarce resource, distributed unevenly in time (because frequent droughts alternate with periods of good rainfall) and space (the eastern half of the country is much wetter than the western half). Increasing demand for water, and decreasing water quality, make careful water management very important in our country. It has been estimated that by the year 2025 there will not be enough water for domestic use (in the home), agriculture (farming), and industry (factories).

**Rainfall**

Our average rainfall is less than 500mm a year, with the driest part of the country receiving less than 200mm/year and the wettest receiving more than 2 500mm/year. Rain does not always fall where it is most needed, and some areas of high demand, such as Gauteng, receive less water than they need. Most rain falls in the narrow belt along the eastern and southern coasts. The rest of the country receives only 27% of South Africa's total rainfall. In addition, hot, dry conditions result in a high evaporation rate.

Water is thus a very scarce resource in South Africa. Large-scale engineering has been used to store water behind dam walls, and to share out water from regions of plenty to regions of need.

**Rivers**

There are few natural lakes in South Africa. We depend on rivers, dams and underground water for our water supply. Approximately 75% of the water flowing from South Africa into the sea occurs along the eastern and southern seaboards, where many short rivers occur. Flowing from east to west is the largest river in the country, the Orange River, which drains most of the rest of the country. Its water comes from sources in the Drakensberg and Maluti Mountains, and it flows into the Atlantic Ocean on the west coast.

**Dams**

About half of South Africa's annual rainfall is stored in dams. We have over 550 government dams in South Africa, which all-together are able to store more than 37 000 million $m^3$ of water. Dams have both positive and negative impacts. They can be useful for people in that they regulate the flow of a river, reducing flood damage and contributing to perennial (returning) rather than seasonal flow. In addition, sediment (which is made of dirt particles) is deposited in a dam, and the growth of aquatic plants (plants that live in water) means that nutrients are removed from the water. Thus water leaving a dam may be cleaner than water entering it. The riverine ecosystem is usually affected negatively by a dam. Changes in the flow of rivers (the amount of water and times when the river has high and low flow), temperature and water quality may cause the variety of organisms living below dams to decrease. Less water flow reduces the river's cleaning ability and this can lead to estuaries becoming silted (silt is material which is finer than sand, but still feels gritty when rubbed).

South Africa's landscape is not well suited to dams. There are few deep valleys and gorges, with the result that most dams are shallow with a large surface area. Together with the hot, dry, climate, this results in much water evaporating from dams. In addition, the high silt load of our rivers means that the capacity of South Africa's dams is quickly reduced as they become silted. The rivers of the Western-Cape carry relatively less silt than those in the rest of the country.

**Water abstraction (removal)**
A growing problem for South Africa's rivers is a lack of water! Reduction in river flow because of abstraction (removal), and damming, has affected many of our rivers, for example those flowing through the Kruger National Park.

**Intercatchment transfer of water**
This involves the transfer of water from catchments (where water is gathered and stored) with good supplies and low demand, to those where demand for water is high and the supply is poor. There are numerous intercatchment transfer schemes already in operation, and more are under construction or proposed. A major scheme is the Orange-Fish River scheme, where water gravitates from the Orange River at the Gariep Dam, and is piped through tunnels and canals to the Sundays and then the Fish Rivers in the Eastern Cape. The massive Lesotho Highlands Water Project is a multi-billion water transfer and hydropower project put in place by the governments of Lesotho and South Africa. It transports water from the upper reaches of the Orange system in Lesotho to the Vaal River for use in Gauteng.

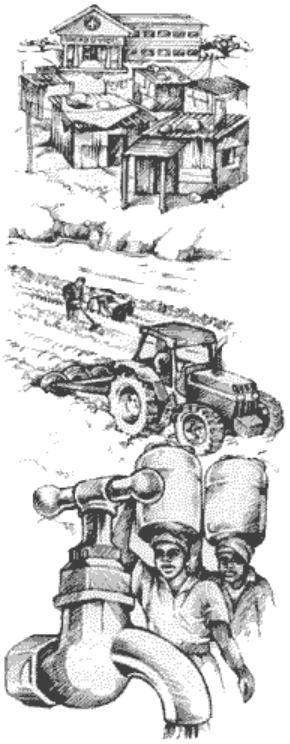
As yet, only a little research has been carried out to establish the ecological consequences of intercatchment water transfers. However, areas of concern include a reduction of streamflow and water levels in one system, changes in water temperature and chemistry, and the movement of invasive species between catchments.

**Water pollution**
Industrial and agricultural pollutants common in South Africa include: agricultural fertilizers, silt, toxic metals, litter, hot water and pesticides. These pollutants affect aquatic ecosystems and human health. Disease-producing bacteria are common in urban waste water, particularly from informal settlements that lack sewage and water purification facilities. For example, Typhoid, Cholera and Gastroenteritis (which are all diseases) are transmitted by water contaminated with untreated sewage. Gastroenteritis is one of three main causes of death in South African children under the age of five.

**Did you know?**
- South Africa has a National Water Bill that attempts to make sure that everyone has access to water and that the water supply can be sustained or kept going.
- Some 12-14 million South Africans do not have access to safe drinking water and some 21 million do not have proper sanitation. Because of this, about 50 000 children die each year from infections.

**Further reading:**
Davies, B. R. and J. Day. 1998. *Vanishing Waters.* University of Cape Town Press.
Camp, S. *A Guide to Water Saving in South Africa.* Umgeni Water, Pietermaritzburg.

## Enviro Fact 2: Sustainable Development



In the past, development and conservation have been in conflict, because development involves using resources and conservation involves protecting resources. Recognising the need for both, the United Nations appointed, in 1987, a commission on environment and development to advise on development and conservation. In the commission' s report called "The Bruntland Report" or "Our Common Future", the concept of sustainable development was emphasised. The report defined sustainable development as "… development which meets the needs of the present without compromising the ability of future generations to meet their own needs". There are many definitions of sustainable development, however, the concept is hardly ever explained or deeply understood, and is thus difficult to put into practice.

**Historical perspective.** During the Industrial Revolution, industries such as mining, manufacturing and large-scale farming became popular and led to development because they enabled the owners to produce a lot of goods for less money. Industrialisation began in Britain and spread to mainland Europe, North America and Japan, all of which became known as the First World. Characteristics of First World countries are high economic growth (growth that occurs when increasing amounts of goods and services are produced over a long time), many different job opportunities, and high incomes. The Soviet Union which is governed under the economic system of communism, became known as the Second World. Third World countries, such as those in Africa, South America and parts of Asia, have slow, if any, economic growth, with a high level of unemployment (in other words, very few jobs are available) and very low incomes, but often lots of natural resources. In fact, the wealth of many First World countries is founded in part on the use of resources (natural and human) from Third World countries.

**Environmental problems.** The environmental problems of the First World are connected with economic wealth, high resource consumption and industrialization. These have contributed to, for example, ozone depletion and global warming. Environmental problems of the Third World, however, can be connected to poverty, high population growth rates, lack of food, shelter and water, and a lack of technical capacity.

**Development as a solution?** The solution to the devastating poverty and environmental problems of Third World countries is often seen as 'development'. For example, the development of Third World countries towards the First World ideas of economic growth through Industrialisation and the use of many resources. However, many people have began to seriously question the wisdom of this approach.

**Limited resources.** It is argued that the Earth's limited resources would not be able to support all the world' s people if everyone used the same amount of resources as those living in First World countries. Mahatma Gandhi, when asked if, after independence, India would attain British standards of living, commented that "… it took Britain half the resources of the planet to achieve its prosperity, how many planets will a country like India require?”

**A different type of development?** Development is usually seen as economic growth, which depends on ever-increasing use of energy and natural resources. This type of development is unsustainable. Another option being suggested involves reusing, recycling and repairing resources instead of just using them. Organisations would thus try to deliver the same high standards of service, but use fewer material resources such as fossil fuels, minerals and water.

**Who benefits?** Third World development programmes that focus on economic growth as a solution to widespread poverty, assume that the benefits of economic growth will trickle down to all members of society. However, economic growth does not always benefit the poor in a country. Many development programmes now give special attention to human needs, getting people to take part in programmes, and the sharing of development benefits, rather than focusing all efforts on financial development.

**Indicators of economic performance.** If we are to move towards sustainable development, we will need tools with which to measure our performance. At present the performance of an economy is measured in term of its gross domestic product (GDP). The GDP is the total value of all the money transactions that take place, and is a poor measure of the effect of economic plans and practices on people and the environment.

However, there are no simple answers to how sustainable development can be measured. As situations and conditions change, so will our understanding of sustainable development change. Sustainable development is not a model to be imposed, but can be seen as a process of learning how to live on the Earth. Ultimately the focus of sustainable living and sustainable development is to find a balance between the social, economic and ecological aspects of our existence.

***Agenda 21***
*Agenda 21 is a global action plan for socially, economically and environmentally sustainable development. It was adopted at the United Nations Conference on the Environment and Development held in Rio de Janeiro in June 1992 (Earth Summit). The conference proposed that Agenda 21 be implemented at the local authority level, and this came to be known as Local Agenda 21. The principles guiding Local Agenda 21 in South Africa are: people-centred development, meeting basic needs, integrated planning and development. Several South African cities and provinces have developed Local Agenda 21 programmes.*

## Enviro Fact 3: Pollution

Pollution is an unwelcome concentration of substances that are beyond the environment's ability to handle. These substances are harmful to people and other living things. In an undisturbed ecosystem, all substances are processed through a complicated network of biogeochemical cycles. During these cycles, substances are taken up by plants, move through the food chain to larger and more complex organisms, and when those organisms die, the substances are decomposed (broken down) into simpler forms to be used again when they are taken up by plants. Biodegradable substances are those that can be broken down by the environment's biological systems. Pollution occurs when the environment becomes overloaded beyond the ability of these normal processing systems.

Examples include:

- An overload of normally helpful substances, such as nutrients, nitrogen and phosphorus.
- An overload of substances that are harmless, and perhaps even necessary in tiny amounts, but toxic in high levels. Copper, for example, is necessary in small amounts for healthy plant growth, but becomes a pollutant if it occurs in greater quantities.
- Synthetic (human-made) compounds that are poisonous in the environment, often even in trace amounts, such as DDT(an insecticide), dioxin, PCBs and organochlorines (dangerous and toxic chemicals).
- Substances that, in any amount, are not biodegradable, such as plastics and highly persistent chemicals like DDT and other organochlorines.
- Some pollutants kill living organisms outright, other sub-lethal pollutants do not kill, but may cause long-term biological damage, interfere with organisms' reproductive cycles, or make them more vulnerable to disease.

**Types of pollution. Pollutants can be grouped according to the main ecosystem which they affect. One pollutant often affects more than one ecosystem.**

| POLLUTANTS AND MAIN SOURCE | HEALTH AND ENVIRONMENTAL EFFECTS |
|---|---|
| AIR | |
| Sulphur dioxide - burning of coal | Acid rain and respiratory (breathing) problems |
| Nitrogen oxides - vehicle emissions<br>Volatile hydrocarbons - vehicle emissions | Combine to form photochemical smog; causes respiratory (breathing) problems |
| Carbon monoxide – vehicle emissions | Restricts oxygen uptake, causes drowsiness, headaches, death |
| Carbon dioxide - burning of coal | Global warming |
| CFCs - aerosol, refrigeration, air-conditioning and foam-blowing industries | Destroy ozone layer |
| Methane - feedlots, rubbish dumps | Global warming |
| Noise - industry, traffic | Affects hearing, stressful |
| Asbestos dust - construction, mining, industry | Asbestosis, mesothelioma |
| FRESH WATER | |
| Sewage - inadequate sanitation | Pathogens cause typhoid, cholera, gastroenteritis; nutrients cause eutrophication (an increase in plant growth in lakes or dams) |
| Fertilizers – agriculture | Eutrophication |
| Silt - agriculture, construction, mining | Smothers aquatic organisms; affects light penetration |
| Pesticides - agriculture, and health services | Toxic; interfere with breeding of mammals and birds |

| | |
|---|---|
| Toxic metals – industry | Health and life threatening |
| Salinisation - industry, agriculture, landfill | Reduced crop yields; scale and corrosion in domestic and industrial water systems |
| MARINE | |
| Sewage - inadequate sanitation | Pathogens cause typhoid, cholera, gastroenteritis; nutrients cause eutrophication |
| Fertilizers – agriculture | Eutrophication |
| Oil spills | Smother marine plants and animals |
| Plastics | Death of marine animals |
| Pesticides - agriculture, and health services | Toxic; interfere with breeding of mammals and birds |
| LAND | |
| Solid waste is classified as hazardous (radioactive, pesticides, medical, poisons), or non-hazardous (domestic, urban, mining, industrial, scrap metal) | Hazardous waste is health- and life-threatening; non-hazardous is unsightly and disposal takes up much space |

**Dealing with pollution**
In the past, most approaches to handling pollution could be summed up by the phrase `dilution is the solution to pollution'. However, pollution levels have increased so much in amount and toxicity that this approach is no longer acceptable. A different approach is source reduction, in other words, a reduction in the amount of pollution where produced.

- Point source pollution: pollutants are produced from a stationary location, e.g. industrial plants, mines, and municipal sewage works.
- Non-point source pollution: this pollution cannot be traced to a specific spot, and is far more difficult to monitor and control. Common examples are veldt fires, motor vehicle emissions, fertilizer runoff, sediment from construction and erosion, plastic packaging, and gases from aerosol cans. Some non-point sources can be addressed by laws, such as banning CFCs (chlorofluorocarbons), or requiring car manufactures to install emission controls.

**Polluter-must-pay principle**
This means that a polluter should bear the costs of avoiding pollution, or remedying its effects. This principle is difficult to apply when the source of pollution cannot be identified, as is often the case with atmospheric pollution. The principle can be usefully applied following a pollution disaster, such as an oil spill from a tanker. However, the consumer often pays for such pollution costs.

**Movement of pollution**
Pollution does not stay in one place but is moved around the world by air and water, as well as by living organisms. Even in Antarctica, birds and marine mammals show traces of pollutants such as DDT and PCBs. Some pollution is deliberately moved abroad. Companies restricted by pollution control regulations at home, sometimes move their plants to other less restrictive countries, as was the case with the plant involved in the Bhopal chemical disaster (the world’s worst industrial disaster during which an insecticide plant released 42 tonnes of toxic gas, exposing 500 000 people to toxic gas and killing thousands). Or while remaining at home, they may sell products abroad, that are classed in their own countries as too dangerous for sale, such as banned pesticides. In some cases hazardous waste may also be shipped abroad, generally from industrialised countries to developing countries willing to accept such waste for a fee, despite the dangers. When such pollutants turn up again in the originating country, as when food is imported that contains banned pesticides, the process is said to be completing the `circle of poison'.

**What can you do**

- *Avoid the creation of waste.*
- *Find out all you can about pollution and protest loudly when you see it happening.*
- *Report air pollution to the Chief Air Pollution Control Officer (CAPCO), Department of Health.*
- *Report freshwater and land pollution to the Department of Water Affairs and Forestry.*

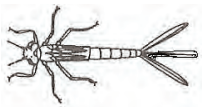
**Criteria to assess learners during this languages lesson**

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| The learner read *The Witness* newspaper article *'A river in crisis'* on their own. | | | | |
| The learner understood what the content of the article was about. | | | | |
| The learner contributed to gathering information either supporting or rejecting the debate question 'River water quality is the sole responsibility of local municipalities/local governments.' | | | | |
| The learner participated in the debate. | | | | |
| The learner acknowledged other people's opinions who did not agree with him/her. | | | | |
| The learner showed sensitivity to other learners during the debate lesson. | | | | |

# ACTIVITY TWO: INVESTIGATING OUR LOCAL RIVER USING miniSASS

**During this NATURAL SCIENCES lesson, learners investigate the water quality of a nearby river, using the miniSASS toolkit to look for visible animal life.**

**History of the miniSASS tool**

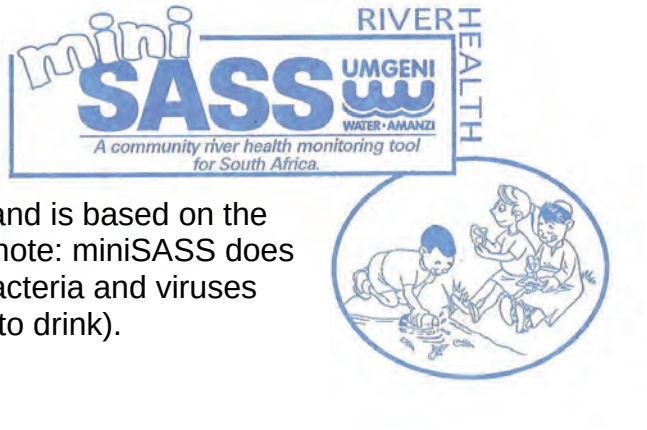


In recent years, scientists have made a remarkable discovery about how to check water quality and it does not have anything to do with water chemistry, or expensive specialised water testing meters. In many cases, all water scientists need to do is find out what organisms (creatures) live in the water.

Researchers count these organisms and compare their numbers with the proportions that scientists have determined should be found there. If the right proportion of species live in the water, things are looking good for that body of water.

Some organisms have a very high tolerance to pollution. If they are found in a river in high proportions, it may be that the river is polluted. When scientists check the health of rivers and other bodies of water, they also look for species that are extremely sensitive to changes in water quality. If these species are found in high proportions, it may be good news for all those who live in that watershed!

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




miniSASS can be used to monitor the health of a river and measure the general quality of the water in that river. It uses the composition of macroinvertebrates (tiny creatures) living in rivers and is based on the sensitivity of the various animals to water quality. (note: miniSASS does **NOT** measure the contamination of the water by bacteria and viruses and thus does not determine if the river water is fit to drink).

**Safety:**
Safety considerations are very important. You must never sample at any site that might be unsafe and never sample alone. At the end of the sampling session, wash your hands thoroughly before eating food.

Remember:

- Never sample alone
- Never go into the water above your knees
- Avoid contact with polluted water
- Choose safe sites
- Wear appropriate clothing
- Take safety gear and a first aid kit

**ACTIVITY:**

**Equipment list:**

- net
- shoes/gumboots
- white container/ice-cream box
- magnifying glass (optional)
- pencil

**How to make your own net:**

Take any piece of wire, for example an old clothes hanger, and bend it into the shape of a circle. Then tie the netting (which can be any porous material) to the wire with a piece of string. And you have a net!

**Method:**

The best sites are those with rocks in fast flowing water. Not all sites have rocks (**rocky type** rivers), but may be largely sandy (**sandy type** rivers).

1. Whilst holding a small net in the current, **disturb** the stones, vegetation, sand etc. with your feet or hands.
2. You can also lift stones and **pick** insects off gently with your fingers or forceps.
3. Do this for about **5 minutes** whilst ranging across the river to **different places** (habitats/biotopes).

4. Rinse the net and turn the contents into a plastic tray and **identify** each group using the identification guide (see page 18).
5. **Mark** the identified insects off on the identification guide.
6. **Add up** the scores to determine the average score.

**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

## 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.

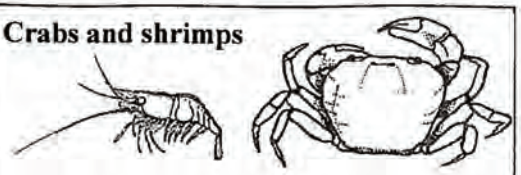
## Worms

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 fed 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

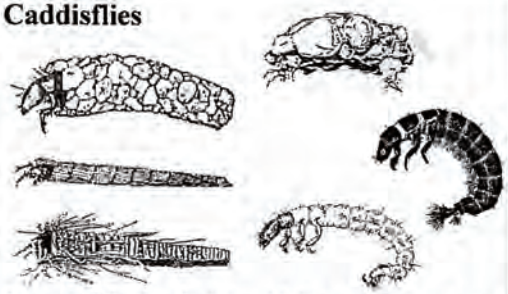


Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs, and eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the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

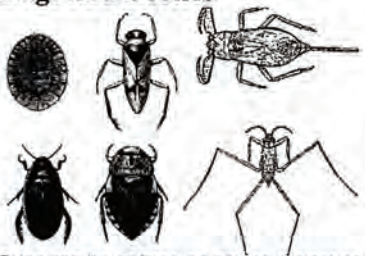
## Damselflies

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.

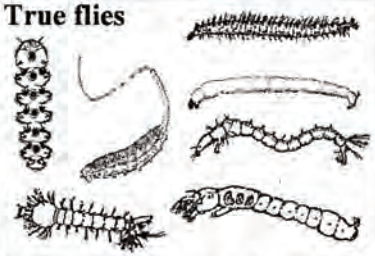
## Minnow mayflies

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.

## Criteria to assess learners during this natural sciences lesson

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| The learner took part in the investigation into river water quality. | | | | |
| The learner collected data using the miniSASS toolkit. | | | | |
| The learner could determine the water quality, using the miniSASS results. | | | | |
| The learner was able to communicate their miniSASS findings effectively. | | | | |

# ACTIVITY THREE: CREATING A DICHOTOMOUS KEY FOR OUR WATER CREATURES

**During this NATURAL SCIENCES lesson, learners categorise the water macroinvertebrates that they found in the previous activity and create their own dichotomous key.**

**READ THE FOLLOWING TO YOUR LEARNERS:**
A dichotomous key is one tool that can be used to identify flowers, animals, rocks, fish, and more! A dichotomous key contains a series of choices that lead the user to the correct name of an item. "Dichotomous" means "divided into two parts." Therefore, a dichotomous key will always give two choices in each step.

For example, a question in a dichotomous key for trees might be something like, "Are the leaves flat or needle-like?" If the answer was "needle-like," then the next question might be something like, "Are the needles in a bunch or are they spread along the branch?" Eventually, when enough questions have been answered, the identity of the tree is revealed.

**CLASS ACTIVITY:**
Designing a Dichotomous Key

1. Distribute to each group of 3-4 learners: thumbtacks, paper clips, wooden ruler, pencil, and plastic pen.

2. Ask the learners to look at the objects and, as a group, ask them to brainstorm how the objects are similar to and different from each other. Then, bring the class together to list on the chalkboard the similarities and differences of the objects. Give the learners about 2-3 minutes to do this.

3. Grouping possibilities could be: metal, plastic, and wood

4. Once this is done tell the learners that scientists uses these similarities and differences to classify the natural world around us. The tool that they use for this is the dichotomous key. From a dichotomous key, one can learn the name of any object/plant/animal, which has been included in the key. In using a key, the learner is led through a series of alternatives until the name of the object/plant/animal is reached. A dichotomous key, in its simplest form, has a few basic rules that make writing one easy.

   Rule 1: Each step involves making choices between two characteristics. These characteristics are grouped 1a and 1b, 2a and 2b, and so forth.
   Rule 2: Each step in a group distinguishes one or more objects (plants, animals, etc.) into two smaller units.
   Rule 3: Each unit either identifies and names an object (plant, animal, etc.) or gives directions as to where to go next in the key.
   Rule 4: At each step, learners must choose **ONE** of the groups, steps, and units at a time and not more than one of each.

**CLASS EXERCISE 1:**
Write on the chalkboard the following four objects:

- tennis shoes
- belt
- celery
- french fries

Ask the learners to list the characteristics of these items and place them into two groups. Group one should include: "tennis shoes" and "belt" as "Clothing Items". Group two should include: "celery" and "french fries" as "Food".

**This is how we could key the above four items.**

Objects: tennis shoe, belt, celery, french fries

| | | |
|---|---|---|
| 1a. | Clothing | Go to 2 |
| 1b. | Not clothing | Go to 3 |
| 2a. | Fits on your feet | tennis shoe |
| 2b. | Fits around your waist | belt |
| 3a. | Crunchy green vegetable | celery |
| 3b. | Crunchy fried snack | french fries |

Now go back to the original objects laid out for the learners (thumbtacks, paper clips, wooden ruler, pencil and plastic pen). Let the learners create a dichotomous key for them as well. Let them do this activity in groups or on their own.

**INDIVIDUAL OR GROUP EXERCISE 2:**

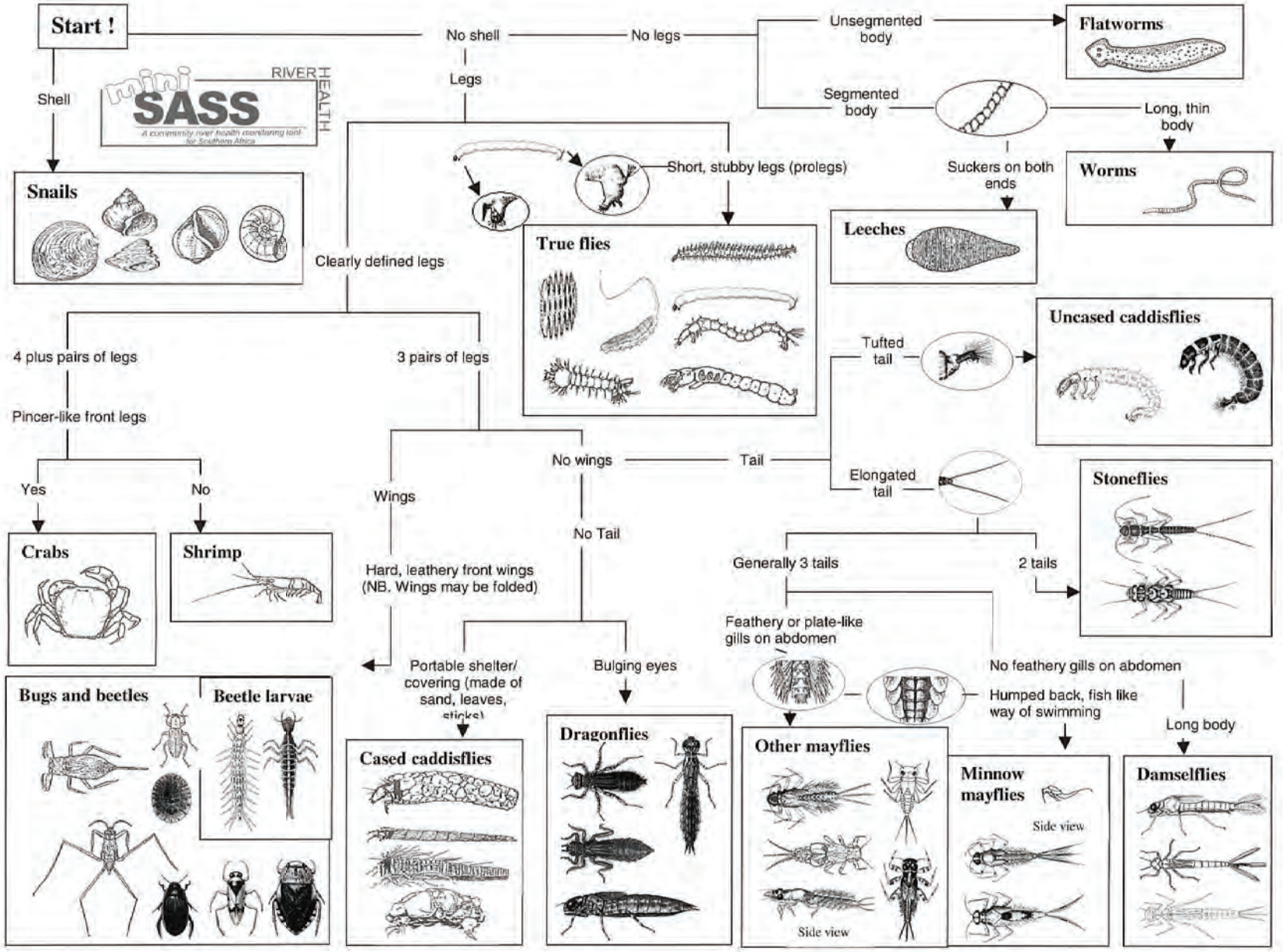
| | | |
|---|---|---|
| 1a. | Objects made of metal | Go to 2 |
| 1b. | Objects not made of metal | Go to 3 |
| 2a. | Flat, without pointed ends, curved on two sides | paper clip |
| 2b. | Round base, pointed, sharp end | thumbtack |
| 3a. | Objects made of wood | Go to 4 |
| 3b. | Objects not made of wood. Made of plastic, round and for writing | pen |
| 4a. | Flat measuring device | ruler |
| 4b. | Round, writing utensil | pencil |

**Did you know? Scientists who design dichotomous keys are called Taxonomists.**

**ASK THE LEARNERS:**

- What happens if there is a new species that is not in the key?
- Can a dichotomous key be too large? Why?

**INDIVIDUAL ACTIVITY:**
List all the water creatures found by the different groups during Activity Two. Individually, learners need to design their own dichotomous key. They can design it like the two done during the class exercises, or they can use a similar way to the example that follows (see page 21).


Start !
No shell
No legs
Unsegmented body
Flatworms
Segmented body
Long, thin body
Worms
Suckers on both ends
Leeches
Shell
Snails
Legs
Short, stubby legs (prolegs)
True flies
Clearly defined legs
4 plus pairs of legs
3 pairs of legs
Pincer-like front legs
Yes
No
Crabs
Shrimp
Wings
No wings
Tail
Tufted tail
Uncased caddisflies
Elongated tail
Stoneflies
No Tail
Generally 3 tails
2 tails
Hard, leathery front wings (NB. Wings may be folded)
Feathery or plate-like gills on abdomen
No feathery gills on abdomen
Humped back, fish like way of swimming
Long body
Portable shelter/ covering (made of sand, leaves, sticks)
Bulging eyes
Bugs and beetles
Beetle larvae
Cased caddisflies
Dragonflies
Other mayflies
Minnow mayflies
Side view
Damselflies
Side view

**Criteria to assess learners during this natural sciences lesson**

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| The learner was able to complete, as part of the class, Exercise 1 on page 21. | | | | |
| The learner was able to complete, on his/her own or in a group, Exercise 2 on page 21. | | | | |
| The learner was able to categorise the water creatures, found during Activity Two, into a dichotomous key. | | | | |

# ACTIVITY FOUR: DRAMA DRAMA DRAMA

**During this ARTS AND CULTURE activity, learners follow a teacher-directed warm-up routine. They also mimic the behaviour of some of the water creatures they found during the miniSASS activity earlier.**

**Note to teacher:** Drama can offer you various skills and techniques which both raise awareness and transform awareness into real-life action. Your role is to stimulate ideas and to act as a catalyst. Instead of offering an education package which has pre-packaged solutions, you can use participatory drama as a process so that your learners can come to terms with many of the issues themselves. Through the drama process, learners are given the chance to 'rehearse' solutions to real-life challenges.

**Getting Started – a space for drama**

Create a physical space that encourages participation. In the classroom, clear the desks and chairs to the side to create an open space. Make sure there is place for everyone to move or sit in a circle.

**Warming Up**

It is a good idea to take the class through some warm-up activities. Warming up in drama is more than just a physical warm-up, it also helps to build a group spirit and encourages the learners to focus (if they are too active it helps calm them down; if they seem lethargic and lazy, it will help you to energize them!)

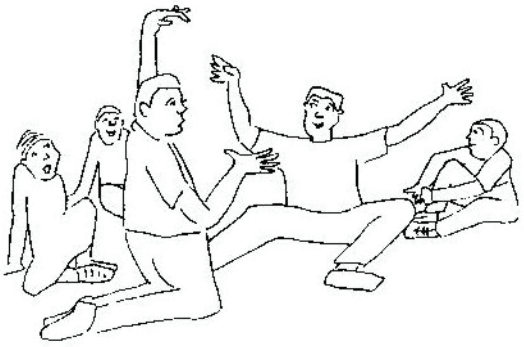
**Warming Up 1: Walking around the space**

1. Everyone in the class should walk around the space that you have created. Each learner can walk in any direction they like and change direction as often as they want to. However, they must be careful not to bump into other learners.
2. Each time you clap your hands, the learners must change direction.
3. Everyone to:
   - Walk

- Run
- Skip
- Hop
- Leap
- Swim
- Jump
- Gallop (like a horse)
- Slide
- Move sideways
- Move backwards
- Move diagonally
- Turn around

4. Call out different situations to your learners and they must change the way they are walking for each situation. *(They must also change their facial expressions!)*
    - You are walking on hot coals
    - You are taking a puppy for a walk
    - You are swimming through syrup
    - You are walking on ice
    - You are jumping from puddle to puddle
    - You are trying to catch a water insect and it's very very fast.

**Warming Up 2: Making body shapes**



1. While the learners are walking around the room, call out a number. The children need to quickly get into a group of that number and keep walking. For example, if you call out "two", the children must pair up with someone, link arms, and keep walking. They must not stop walking or worry about who they have paired up with – they must pair up with the closest person. If you call out "four", the four closest children must pair up with each other.
2. After this has been done a few times with different numbers, divide the children into groups of five or six. Call out different shapes, and each group should make that shape with their bodies, for example "square" …. "rectangle"… "triangle" …. "circle". The children can make the shape standing up, sitting or lying down but everyone in the group must be part of the shape.
3. Since our theme in this series of lesson plans is WATER, ask the children to form the letters W A T E R. Then try the chemical formula for water, $H_20$.

**CLASS ACTIVITY:**

Hand out the information sheet on water macroinvertebrates (page 18). If you have already done Activity Two, your learners will have seen some of the water creatures on this page and noticed their behaviour. Let your learners read about the different creatures they may have seen to refresh their memories.

Next, with everyone standing with lots of space around them, learners need to mimic some feature of the water creatures' behaviour that you are about to call out. It may be the way the water creature swims, feeds or moves on land or water.

- Flat worm
- Leech
- Snail
- Stonefly nymph
- Mayfly nymph
- Crab
- Shrimp
- Dragonfly nymph
- Dragonfly
- Caddisfly

You may like to repeat this exercise twice: once letting the learners remember what they saw/read during the earlier miniSASS water study and a second time by reading about each creature to the learners and then calling out the name.

**The teacher-learner relationship**
In this kind of work, the teacher becomes part of the learning community rather than an all-knowing figure. This means that you, as a teacher, need to:

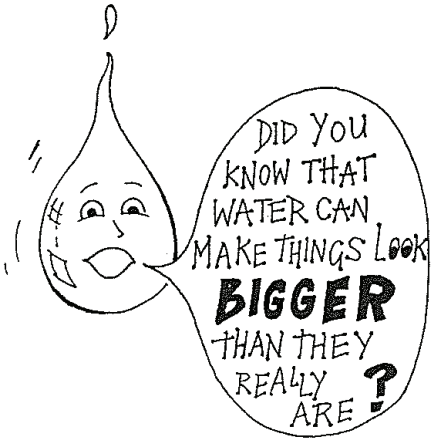
- be a good listener – listen carefully to what each learner offers and acknowledge their contribution;
- create an enjoyable atmosphere in your lesson; this does not mean that the work you do is only about 'fun', but that you create an atmosphere which allows learners to be creative, to try things out and to take initiative;
- be more of a facilitator than a 'teacher', guiding the learners' activities;
- ask the right questions – instead of telling the learners everything they need to know, see if you can draw out many of the ideas and perspectives from the learners themselves;
- be motivating, flexible, creative and encouraging;
- create a 'safe environment' in which learners feel free to participate. This means an atmosphere which is non-judgemental and in which learners feel they can make a contribution without being laughed at, scolded or ignored. Encourage and nurture the learners.

**Criteria to assess learners during this arts and culture lesson**

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| The learner followed the teacher's instructions. | | | | |
| The learner contributed to the warm-up drama routine by being actively involved. | | | | |

# ACTIVITY FIVE: JUST FOR FUN: MAKING A MAGIC MAGNIFIER

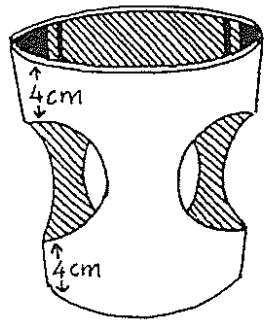
**Did you notice that some of the water creatures you looked for during Activity Two looked enormous while under the water? And then, when you scooped them out of the water, they weren't quite so big! Water can make things look bigger than they really are.**

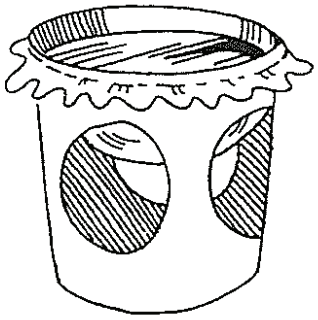



**You will need:**

- a soft plastic bucket (25cm diameter works well)
- clear plastic wrap
- four elastic bands knotted together in a circle
- a sharp kitchen knife
- a ballpoint or felt-tip pen

**What to do:**



1. On the sides of the bucket draw three evenly spaced circles (big enough to put your hands through) on the outside of the bucket. Leave at least 4cm at the top and bottom of each circle. Carefully cut out the circles.

2. Cut a piece of clear plastic big enough to cover the top of the bucket with a 15cm overlap all around.

3. Put the plastic loosely over the top of the bucket and keep in place with the rubber bands. Press down gently so that it sags into the bucket. Slowly pour lukewarm water onto the plastic. Add as much as you can without overflowing. The plastic should sag at least 10cm below the rim of the bucket.

   You have now made a convex water lens.

4. Take your bucket out of the sunlight and place your objects into the bucket through the cut-out holes. Look at the objects, like a paperclip, pencil or sweet, through the lens – you'll be amazed!!

# SUGGESTED

# LESSON PLANS

# GRADE 9

# ACTIVITY ONE: SICK RIVERS = SICK CITIES?

**In this LANGUAGES activity, learners find out more about the state of South Africa's rivers. A newspaper article forms the focus point for a general class discussion around river health.**

**CLASS ACTIVITY:**
Photocopy *The Witness* newspaper article *'Rivers of filth across KZN'* (on page 2) and hand a copy to each learner in your class to read.

**ASK YOUR LEARNERS** *(this can either be a class or small group discussion)*

1. What was your reaction to the newspaper article?
2. Do any of you live near a river? What is the river like?
3. Have you seen effluent (sewage or waste) going into the river (either because of a broken/blocked pipe) or because someone was illegally dumping into the river? How did you feel? What happened? Did you tell your parents, a friend, the municipality? Did you not know what to do?
4. What seemed to be the main issue in the newspaper article?
5. What needs to be done to solve this problem/issue?
6. Is this an important issue? Why? Why not?
7. What are practical things that you, as an individual, and your family can do in the home, to be part of the 'solution' and not 'part of the problem'?
8. The famous conservationist, Dr Ian Player once said "if the river running through your city is sick, then your city is sick". What do you think he means by this statement? Do you agree with it? Why? Why not?
9. What effect does sewage and waste going into a river, have on the biodiversity (the variety of life in an area, including the number of different species) of the river?
10. Does this affect people? How?
11. What are ways that we can test whether a river is 'sick' or not?
12. Have any of you ever done water testing? What did you find/see?
13. Ask each learner to pose a water or water quality question, related to the newspaper article, to the rest of the group/class.

**INDIVIDUAL ACTIVITY:**

- If your school has access to **Google Earth**, then type in the name of your village, town or city and see if you can find your school. Next, see if you can find the nearest river to your school. If there are no rivers near your town or city, then choose a place that you have visited and see if there are any rivers near/in/around it.

- Once, you have located and identified a stream, river or dam, do an Internet search and find out if anything has been written on that stretch of water, especially its 'health'. Print out the articles and make a display in your classroom. Happy river health 'surfing'!

# Rivers of filth across KZN

09 Oct 2008 *Nalini Naidoo*

"The sewage problem in Howick is an absolute disaster and is totally unacceptable. If allowed to continue, it will make Delmas look like a Sunday school picnic".

This dire warning came from Lin Gravelet Blondin KZN pollution control director in the Water Affairs and Forestry Department.

Delmas is a town in Mpumalanga that experienced a typhoid outbreak in September 2005. More than 287 cases of typhoid were reported; four people died and more than 1 400 had diarrhoea. The cause? The groundwater system had become polluted with sewage.

Gravelet Blondin said it is unacceptable that sewage is flowing freely through people's gardens and streets where children play.

The springs the Siphumele and Thokoza communities near Howick use are at times immersed in sewage-polluted water and the pump stations are not working properly, resulting in raw sewage regularly being dumped into the surrounding area.

He added that there are problems with sewage pollution right across the country as well as in KZN. "It is worse in smaller municipalities, who do not have the capacity, finance and expertise to deal with the problem. However, bigger municipalities have also experienced their fair share of problems, despite having a lot more finance and expertise."

Pietermaritzburg experienced a sewage overflow in Jesmond Road this week. The very vocal residents were quick to register their horror and the municipality's sanitation division reacted quickly. By yesterday morning, all signs of the mess had been cleared up. According to officials, the problem was caused by a blocked pipe. uMngeni Municipality was also hard at work carrying out repairs, following earlier reports on the situation there in *The Witness*.

According to Gravelet Blondin, towns that have experienced severe sewage problems are Mooi River, Howick, Richmond and Kokstad. He said the day he visited Mooi River, the situation seemed more under control, but there was definitely evidence of past pollution from pump station failure. Work on the systems in Kokstad and Richmond is continuing, but a lot more needs to be done. The department and other role-players will meet next Wednesday to find more long term solutions.

Dave Still, chairman of the Duzi Umgeni Conservancy Trust (DUCT), has said the national Treasury gives municipalities grants equivalent to more than R60 per indigent family per month to help them to maintain sanitation services to the poor. He believes this money needs to be appropriately utilised. Municipalities can also apply for funding from national government to repair and renew sewerage infrastructure. "If they cannot find the money to fix these problems, they should take the money from their budget for bonuses for senior management," he said.

Local municipalities can take a leaf out of Johannesburg's book, where the water utility has started a R5 billion upgrade of the city's sanitation and water system.

According to reports, the project is part of the city's R1 billion annual programme over the next five years to upgrade and rehabilitate infrastructure in the city to reduce both water and sanitation pipe bursts.

*Source: The Witness newspaper*

## Criteria to assess learners during this languages lesson

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| The learner read the article *'Rivers of filth across KZN'* on his/her own. | | | | |
| The learner actively participated in the group/class discussion after having read the article *'Rivers of filth across KZN'*. | | | | |
| The learner's answers to the questions were accurate and thoughtful. | | | | |

# ACTIVITY TWO: PREPARING FOR OUR RIVER HEALTH INVESTIGATION

**Following on from Activity One on river health, learners investigate suitable equipment needed for water quality monitoring in a local river or body of water. During this TECHNOLOGY lesson, they will design, cost and build some of the necessary equipment.**

South Africa has been a world leader in biomonitoring techniques using macroinvertebrates. The most successful of these is the South African Scoring System version 5 (SASS5). miniSASS is based on SASS and also uses the presence of macroinvertebrates to indicate the "health of a river". Where SASS contains 90 different macroinvertebrate classes, miniSASS only has 13 different classes, allowing for simpler identification and understanding.

**Macroinvertebrates**

**What are they?**

Macroinvertebrates are animals that have no backbone and can be seen without using a magnifying glass.

**Why are they used for biomonitoring?**

- Different macroinvertebrates have different sensitivities to pollution. The higher their score, the more sensitive they are.
- They are generally easy to collect and identify.
- They are relatively sedentary which allows the source of the pollution to be detected.
- They integrate the water quality conditions at a site, providing an overall measure of the "health" of a river.
- They can provide a picture of the historical water quality at a site.

**What is the importance of water quality monitoring and management in South Africa?**

Fresh water is essential for the daily life of all aquatic and terrestrial organisms. It is used in all spheres of life, namely agriculture, industry, biodiversity conservation, sanitation and hydration. However due to the amount of rainfall that South Africa receives, it is classified as a water stressed country. This means that if we do not monitor, manage and conserve our current water bodies, we will be placing them and the population under tremendous stress in future!

As the general public, we can play a part in making a difference to managing freshwater resources in a community. miniSASS has the potential to be a powerful **'red flag'** indicator for the identification of aquatic pollution sources. By using miniSASS we can actively take an interest and management in the health of freshwater bodies in our community.

Your interest and knowledge can be enhanced by adopting a local river in your community and monitoring it over time, identifying sources of pollution and taking **local action** to make a difference. You could also encourage more members of the community to take positive action towards monitoring and conserving water.

### Additional resources:

- The Water Research Commission - www.wrc.org.za
- GroundTruth – biomonitoring services and environmental consultants - www.ground-truth.co.za
- Wildlife and Environment Society of South Africa - www.wessa.org.za
- Department of Water Affairs and Forestry – www.dwaf.gov.za
- Share-Net resources for fieldwork and environmental learning - sharenet@wessa.co.za

### Glossary:

- **Biomonitoring**: The monitoring of biodiversity using biological organisms.
- **Biodiversity**: Diversity within species, between species and of ecosystems.
- **Ecosystem:** A complete community of living organisms and the nonliving materials of their surroundings.
- **Sedentary**: Inactive, motionless, not moving.
- **Conservation**: The maintenance of environmental quality and functioning.

### INDIVIDUAL ACTIVITY:

In Activity Three, learners will investigate the health of a nearby stream or river using the miniSASS toolkit. Some of the equipment that will be needed includes the following:

- Safety gloves to collect specimens
- Score sheet
- Container to keep small water creatures in, for the duration of the water quality monitoring period
- Net to capture water creatures

In preparation for Activity Three, learners need to choose two pieces of equipment (listed at the bottom of page 3) and do their own research (either through the Internet, store catalogues or by visiting relevant shops in town) on this equipment in terms of their:

- Safety
- Suitability of materials
- Fitness for purpose
- Cost
- Manufacturing method

They need to bear in mind that they will be 'designing' and building at least one piece of equipment themselves so they should keep notes on all the equipment they see. They may find that they are able to integrate the different ideas into one design.

All learners need to share their findings by reporting back to the rest of the class what they found during their research.

**INDIVIDUAL ACTIVITY:**

- Design, cost and make a piece of water quality monitoring equipment, based on your earlier research.

Learners need to write clear instructions for the development of their piece of equipment. This needs to include all materials needed, formal drawing or drawings with dimensions or quantities and a manufacturing sequence (such as flow diagrams or charts).

*All drawings and work needs to be kept in a file and handed in – this can be added to learners' assessment files.*

**Criteria to assess learners during this technology lesson**

| **Criteria** | **Exceeded requirements of the Learning Outcome** | **Satisfied requirements of the Learning Outcome** | **Partially satisfied requirements of the Learning Outcome** | **Not satisfied requirements of the Learning Outcome** |
|---|---|---|---|---|
| Learner was able to analyse existing products needed for water quality monitoring in terms of safety, suitability, fitness, cost and manufacturing method. | | | | |
| Learner was able to develop a plan of clear instructions, together with all materials needed, formal drawings and manufacturing sequence for making their piece of water quality monitoring equipment. | | | | |
| Learner successfully constructed their chosen piece of water quality monitoring equipment | | | | |

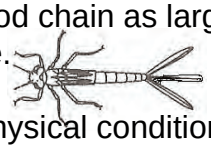
# ACTIVITY THREE: INVESTIGATING RIVER HEALTH USING THE miniSASS TOOLKIT

**During this NATURAL SCIENCES exercise, learners investigate the water quality, based on visible animal life, of a nearby stream, river or body of water. They use the miniSASS toolkit and their equipment from Activity Two to undertake this activity.**

**ACTIVITY:**
**Photocopy the following information for your class:**

Streams, rivers, wetlands and dams are homes for many small animals called macroinvertebrates. These animals generally include insects, crustaceans, molluscs, arachnids and annelids. The term macroinvertebrate describes those animals that have no backbone and can be seen with the naked eye.

These animals live in the water for all or part of their lives, so their survival is related to the water quality. They are significant within the food chain as larger animals such as fish and birds rely on them as a food source.



Macroinvertebrates are sensitive to different chemical and physical conditions. If there is a change in the water quality, perhaps because of a pollutant entering the water, or a change in the flow downstream of a dam, then the macroinvertebrate community may also change. Therefore, the richness of macroinvertebrate community composition in a water body can be used to provide an estimate of water body health.

**Water conditions and macroinvertebrates**
Environmental modifications or pollution can alter macroinvertebrate communities. Poor catchment management can exaggerate the turbidity (clarity) of water. In highly turbid water, the light penetration is reduced affecting the photosynthesis of plants and also increases the temperature of water. The suspended solids may clog respiratory surfaces or interfere with feeding appendages. Filter feeders receive reduced nutritional value and expend more energy to collect food, as otherwise they will starve. High levels of suspended solids may begin to settle and change the composition of the bed of the water body as it coats rocks and vegetation. This can affect movement, feeding, habitat and reproduction of some macroinvertebrates.

The riparian vegetation (plants growing along the edge of a river) balances the temperature in a healthy aquatic system. If this vegetation is cleared, it gives rise to more light penetration and an increase in turbidity from exposed soil. Industrial discharges or stormwater runoff from hot surfaces (such as roads and carparks) could increase the temperature quickly and discharges from dams could release cooler water. Some macroinvertebrates such as stoneflies cannot cope with such changes.

High levels of nutrients in the form of nitrogen and phosophorus from fertilizers and wastewater can activate excessive algal growth (algal blooms). The death and decay of these algae can produce toxins and stagnant

conditions. In these conditions, macroinvertebrate community diversity is usually reduced but there is generally an increase in the abundance of a few species. These macroinvertebrates are able to take advantage (they are opportunistic) of the altered conditions and exploit the excess of food supply.

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


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 quality of the water in that river and it is a technique that has been developed in South Africa. It uses the composition of macroinvertebrates living in rivers and is based on the sensitivity of the various animals to water quality.

**Safety:**
Safety considerations are very important. You must never sample at any site that might be unsafe and never sample alone. At the end of the sampling session, wash your hands thoroughly before eating food.

Remember:

- Never sample alone
- Never go into the water above your knees
- Avoid contact with polluted water
- Choose safe sites
- Wear appropriate clothing
- Take safety gear and a first aid kit

**Equipment list:**

- net
- white container/ice-cream box
- pencil
- magnifying glass (optional)
- shoes/gumboots

***Note to teacher: The focus question for this exercise is to examine the water quality of your chosen river/body of water using visible animal life.***

**Method:**
The best sites are those with rocks in fast flowing water. Not all sites have rocks (**rocky type** rivers), but may be largely sandy (**sandy type** rivers).

1. Whilst holding a small net in the current, **disturb** the stones, vegetation, sand etc. with your feet or hands.

2. You can also lift stones and **pick** insects off gently with your fingers or forceps.
   Do this for about **5 minutes** whilst ranging across the river to **different habitats** (places).
3. Rinse the net and turn the contents into a plastic tray/container and **identify** each group using the identification guide on page 9.
4. **Mark** the identified insects off on the identification guide on page 9.
5. Use the score sheet below to determine the average score. Write these scores on the chalkboard*.

** To see how reliable and accurate the learners' investigations and data collection was, ask all the learners (or groups if they did this activity in groups) to write up their scores on the chalkboard. If the learners were conducting this investigation within a small area, their results should be similar. If the results differ greatly, find out why.*

**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 using the table on page 8.

| 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.

| **ECOLOGICALCATEGORY (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 |

5. Write a paragraph on **the meaning of your data** (scores), comparing them with the focus question.

6. What other investigations (other than investigating visible animal life) could you do to confirm your findings about the health of this river/body of water?

*Send your results to **minisass@ground-truth.co.za** to contribute to a developing picture of river quality in South Africa.*

**Criteria to assess learners during this natural sciences lesson**

| **Criteria** | **Exceeded requirements of the Learning Outcome** | **Satisfied requirements of the Learning Outcome** | **Partially satisfied requirements of the Learning Outcome** | **Not satisfied requirements of the Learning Outcome** |
|---|---|---|---|---|
| The learner conducted the water quality monitoring investigation. | | | | |
| The learner collected and interpreted data from the water quality monitoring investigation. | | | | |
| The learner was able to write a paragraph on the meaning of his/her data. | | | | |
| The learner was able to suggest further investigations which would help confirm the findings of the miniSASS investigation. | | | | |

## 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 fed on.

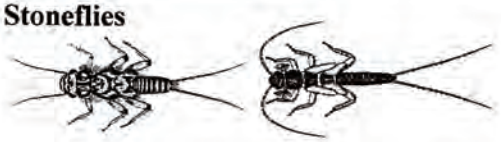
## Snails

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

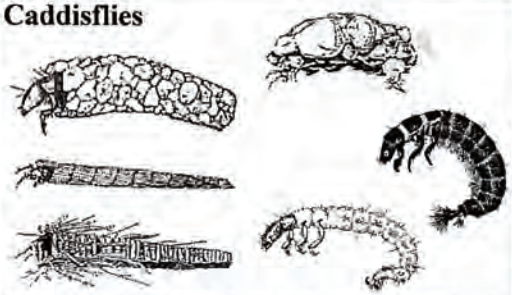
Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs, and eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the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

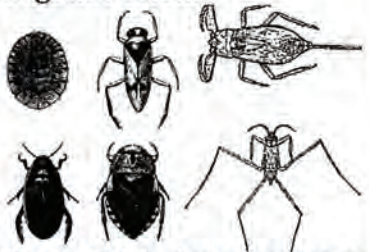
## Damselflies

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.

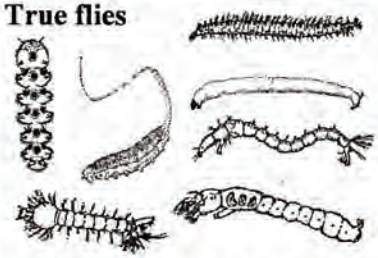
## Minnow mayflies

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.

# ACTIVITY FOUR: SO … WHO'S RESPONSIBLE FOR WATER AND WATER QUALITY IN SOUTH AFRICA?

**During this MATHEMATICS data handling activity, learners find out how water finds its way to the taps in their homes and how it leaves their homes. They also collect and summarise information on two important South African laws around the provision of water services.**

According to the Constitution of the Republic of South Africa enacted in 1996, everyone has the right to have access to 'sufficient food and water.'

**Water, our national resource**

Water falls from the sky as rain. It flows across the surface of the land into streams, then rivers and out to the sea. Humans collect water from the streams and rivers for drinking and irrigating their fields and for use in manufacturing and mining. In a country like ours which does not receive much rain, it is necessary to try and save as much of the rain water as is possible for these uses.

So, we build dams which store water and make it available all year round. To make it easier for people living in towns and cities to have access to this stored water it is led from the dams in pipes to storage areas (reservoirs) in the cities.

Here it is purified (treated) and then piped (reticulated) into homes and factories. For this to occur various institutions and well-managed infrastructure must be in place.

**Water Services Institutions**

The government has the primary responsibility of creating the institutional arrangements and structures for ensuring that the people's rights to water are satisfied.

The national government has created a department known as the Department of Water Affairs and Forestry (DWAF) under the direction of the Minister of Water Affairs and Forestry. This department is responsible for establishing, throughout the country, dams for the storage of the national water resource and establishing norms for preventing the pollution of water flowing into the rivers. The department also establishes bodies known as Water Boards whose task it is to provide water services to local government.

According to the Constitution, the responsibility for providing water to towns and rural communities rests on local government authorities. This means that the Regional Councils and Municipalities must undertake responsibilities for

obtaining supplies of water from the Department's storage dams, or a Water Board, and purifying and reticulating that water.

**ACTIVITY:**

1. Find out how piped water gets to your house and how it leaves your house. Does it come from a dam or reservoir? You may need to contact your local municipality or water board. You might want to interview people in the area using a questionnaire, or conduct an Internet search. (Keep a record of all the methods you use to gather your data.) Draw the pathway of water from rain/groundwater to your bathroom. Remember to include any purification that takes place. (If some learners live on farms and have streams/springs on the farm, show how it is pumped to the house – is it filtered, chlorinated?) Draw the pathway of the water leaving your house – where does it go?

2. There are two very important laws around the provision of water services in South Africa. (***Teacher:*** *they are the National Water Act of 1998 and the Water Services Act of 1997*). What are they? And what are their main objectives? Do an Internet search or use your local library. You may even decide to telephone or write to the Department of Water Affairs and Forestry.

**Criteria to assess learners during this mathematics lesson**

| **Criteria** | **Exceeded requirements of the Learning Outcome** | **Satisfied requirements of the Learning Outcome** | **Partially satisfied requirements of the Learning Outcome** | **Not satisfied requirements of the Learning Outcome** |
|---|---|---|---|---|
| The learner was able to select and use different and appropriate sources in order to find out how water reached and left his/her home. | | | | |
| The learner's drawing accurately reflected the pathway of rain/groundwater to their bathroom and included the appropriate information. | | | | |
| The learner was able to select and use different and appropriate sources in order to find out what important South African laws there are around the provision of water services. | | | | |

# ACTIVITY FIVE: CREATING A WATER QUALITY ACTION PLAN

**During this NATURAL SCIENCES lesson, learners develop a River Action Plan with aims, goals and objectives. They then implement the Action Plan, evaluate it and review it.**

**NOTE TO TEACHER:** Now that learners know the quality of their stream or river, they can create their own River Action Plan. If their water quality monitoring showed a "poor" or "very poor" stream or river, they may consider an Action Plan which involves constant water testing and water quality monitoring, as well as community meetings, litter clean-ups and removing invasive alien plants and trees. Some rivers/streams will have shown good conditions, even approaching natural conditions and learners may then decide to have a River Action Plan to promote the enjoyment of the river and its surrounds, such as a small field guide trail book which identifies all the plants, trees and birds in the area or appropriate environmental information signage along a well maintained and managed river trail.
This can be done either in a group or as an individual activity. Learners will need to write up their Action Plan and submit it to you, the teacher, for guidance and assessment. You may like to make this a term-long or year-long project for learners – Write up an Action Plan, Implement the Action Plan, Report on the Action Plan.

**GROUP OR INDIVIDUAL ACTIVITY:**
Learners need to formulate an action plan for the river or stream they monitored in Activity Three. Once formulated, with guidance from you the teacher, they need to implement their Action Plan (over a term or a year), and then review and report on it.

**What is an Action Plan?**
An action plan is like a road map – it shows you where you are, where you are going, and how you are going to get there.

The aim of an action plan is to allow your group to move from what you know, to eventually co-ordinating and implementing actions that will have a beneficial impact on the river and its water quality. An action plan will help to focus your activities.

**Getting everyone involved**
Before you even begin drawing up an action plan, you need to make sure that all stakeholders, people who live, work, go to school or run a business near the river you investigated, are aware of your activities. You will achieve much more when the whole community understands what you stand for, and what you are trying to achieve. Also, ensure that relevant government water and land managers, local government and conservation groups are involved.

Remember not to exclude groups or individuals that may be contributing to the decline of water quality or groups who are already working on water issues in

your area. Good outcomes are based on the principle of co-operation not confrontation.

**From Awareness to Action**
The nature of the problem will usually determine what actions are most suitable. Depending on the situation you may wish to promote better farming practices, replant trees, remove litter or gain media coverage for your activities.

**Aims**
An aim is a broad statement that says what you are trying to achieve. For example, you may aim to:

- Create a cleaner, less polluted waterway
- Improve water quality by reducing erosion
- Promote the natural beauty of the river for use by the community and tourists

**Goals**
You now need to set your goals, which should flow from your aim. Make sure the goals are achievable, tangible and positive. Place realistic time frames on your goals, and remember to prioritise them.

Possible goals could include:

- Increasing indigenous vegetation along the waterway
- Removing litter and exotic species from the waterway
- Developing a river walking trail
- Developing a trail booklet

**Objectives**
Once you have created your goals, you should create one or more definable and measurable objectives for reaching each goal. Using the existing example, objectives could be to:

- Plant at least 10 indigenous trees
- Remove at least 50% of exotic plants from the waterway

Once you have determined specific objectives, you might like to create a timetable for each, and place someone in charge of reaching each objective.

**Evaluate your Progress**
Once you begin putting your plan into action, you will need to evaluate your progress by reviewing your aims, goals and objectives. This evaluation can be quite simple, you should go through each of your objectives and determine if that objective was met or not. If you did not meet your objective, try to work out reasons for this.

**Review your Plan**
Even if you have achieved what you originally planned, you need to go back and examine the whole process. Even the most successful programme can be critically reviewed and improved.

## Criteria to assess learners during this natural sciences lesson

| Criteria | Exceeded requirements of the Learning Outcome | Satisfied requirements of the Learning Outcome | Partially satisfied requirements of the Learning Outcome | Not satisfied requirements of the Learning Outcome |
|---|---|---|---|---|
| The learner contributed to formulating a River Action Plan which included aims, goals and objectives. | | | | |
| The learner implemented the River Action Plan. | | | | |
| The learner evaluated his/her River Action Plan. | | | | |
| The learner reviewed his/her River Action Plan. | | | | |

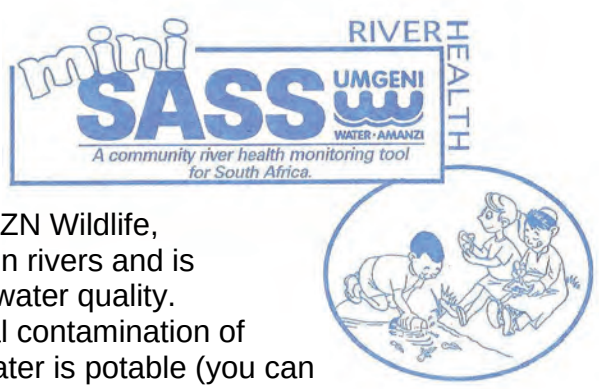
# SUGGESTED

# LESSON PLANS

# GRADE 11

# 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.

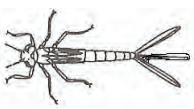
## So, are you ready for some environmental action and to find out the condition of your stream or river?

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.

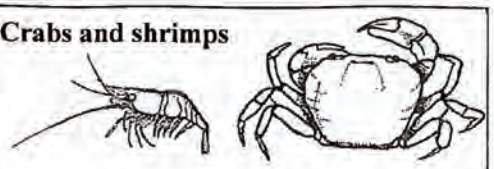
## Worms

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 fed 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

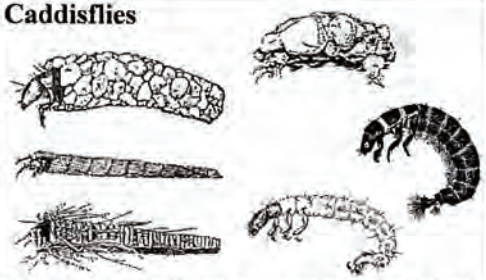


Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs, and eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the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

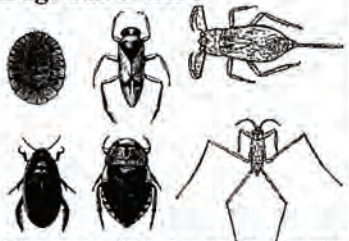
## Damselflies

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.

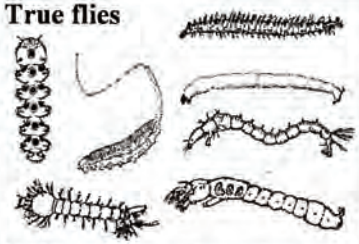
## Minnow mayflies

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.

**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.

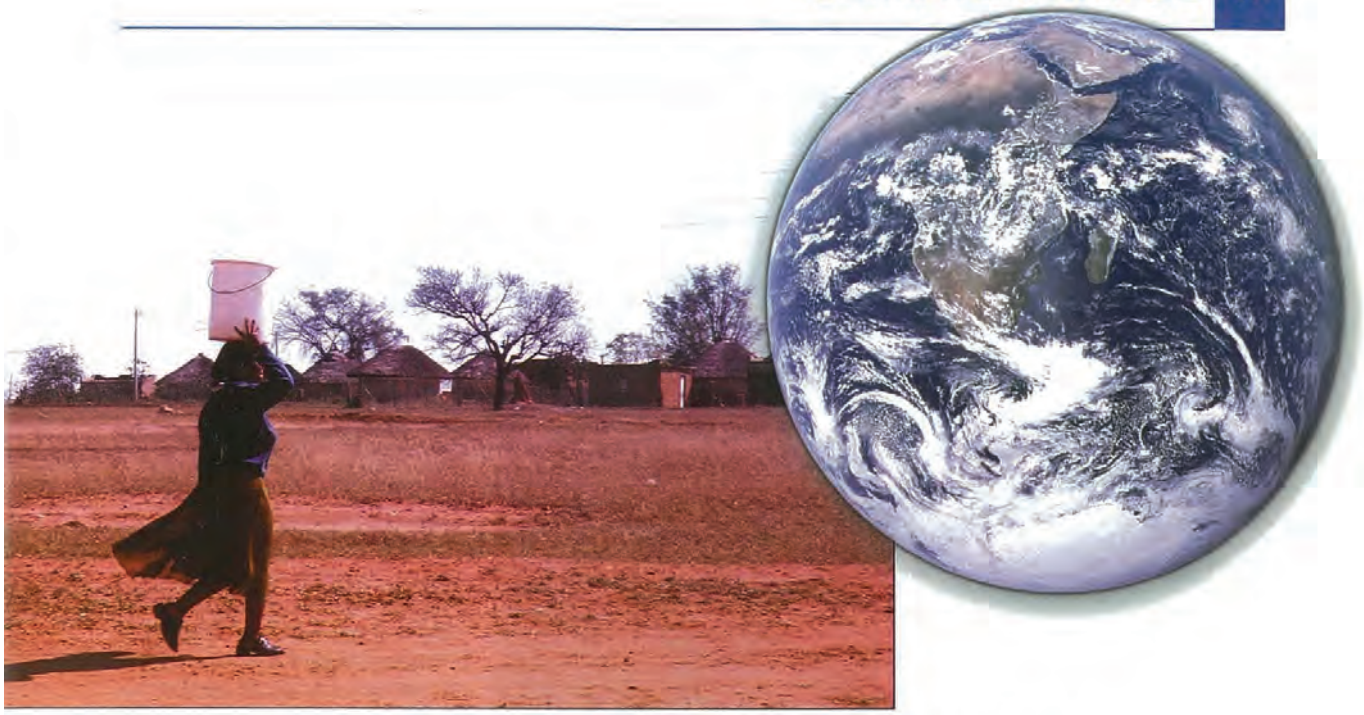
**Criteria to assess learners during this life sciences lesson**

| 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.***

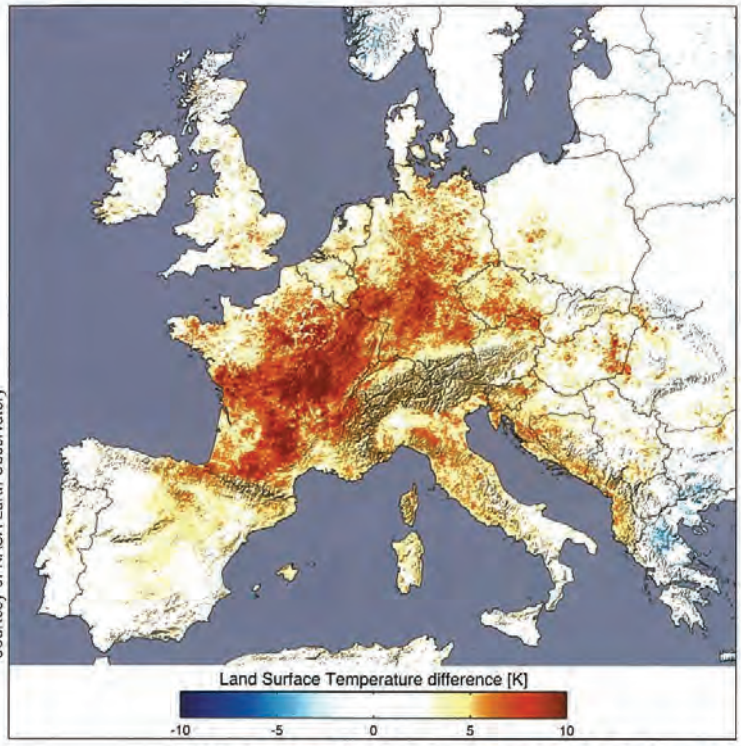
Most scientists agree that climate change is happening, and will continue to happen in the foreseeable future even if the global gas emissions responsible for this phenomenon are curtailed significantly in the short to medium term. According to South Africa's National Climate Change Response Strategy, 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 as 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 Müden 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 Müden, 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.bpb.wits.ac.za or E-mail: Luanne@crg.bpb.wits.ac.za

The Water Wheel January/February 2006

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**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?

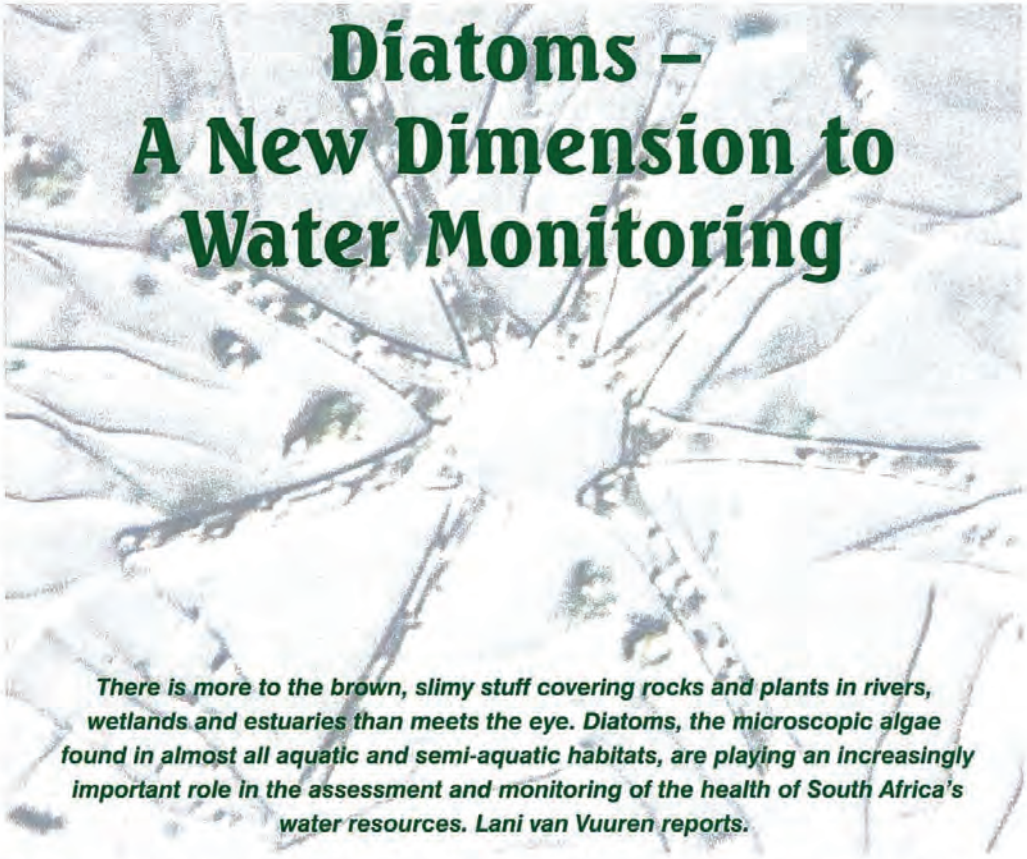
5. Can diatoms be used to assess conditions in past river systems? Explain.

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 chemoautrophic 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 provide 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."**

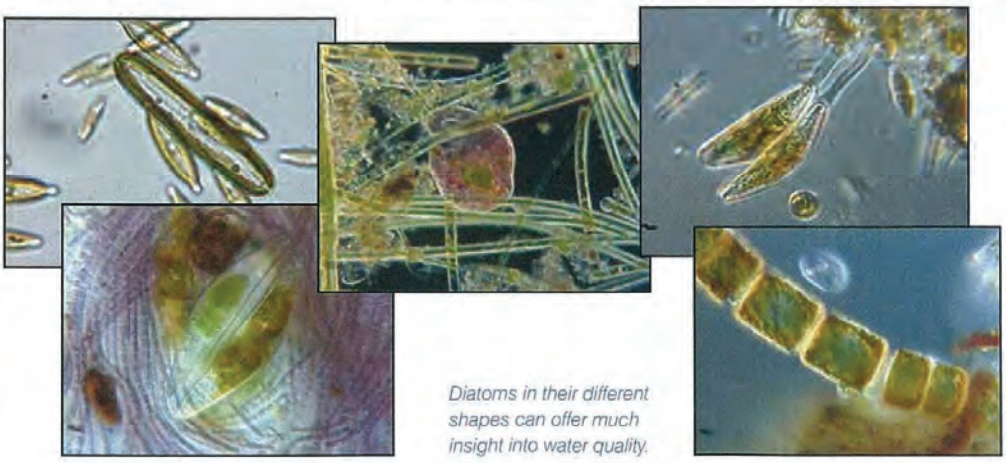
Diatom-based monitoring has proved to be very useful in regions such as Europe to monitor shared rivers and water resources, reports Dr Jonathan Taylor of the School of Environmental Sciences & Development at North West University. This cosmopolitanism does have a down side, however. "Typically, when 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

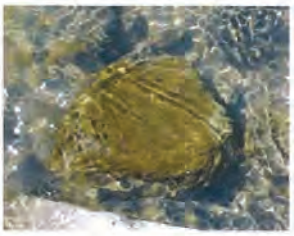
South Africa has a long and proud history of diatom research, mainly as a result of the work of pioneer diatom specialists such as the late Dr Bela Cholnoky. In fact, unbeknown to many, South Africa possesses one of the most comprehensive collections of diatoms in the world.

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

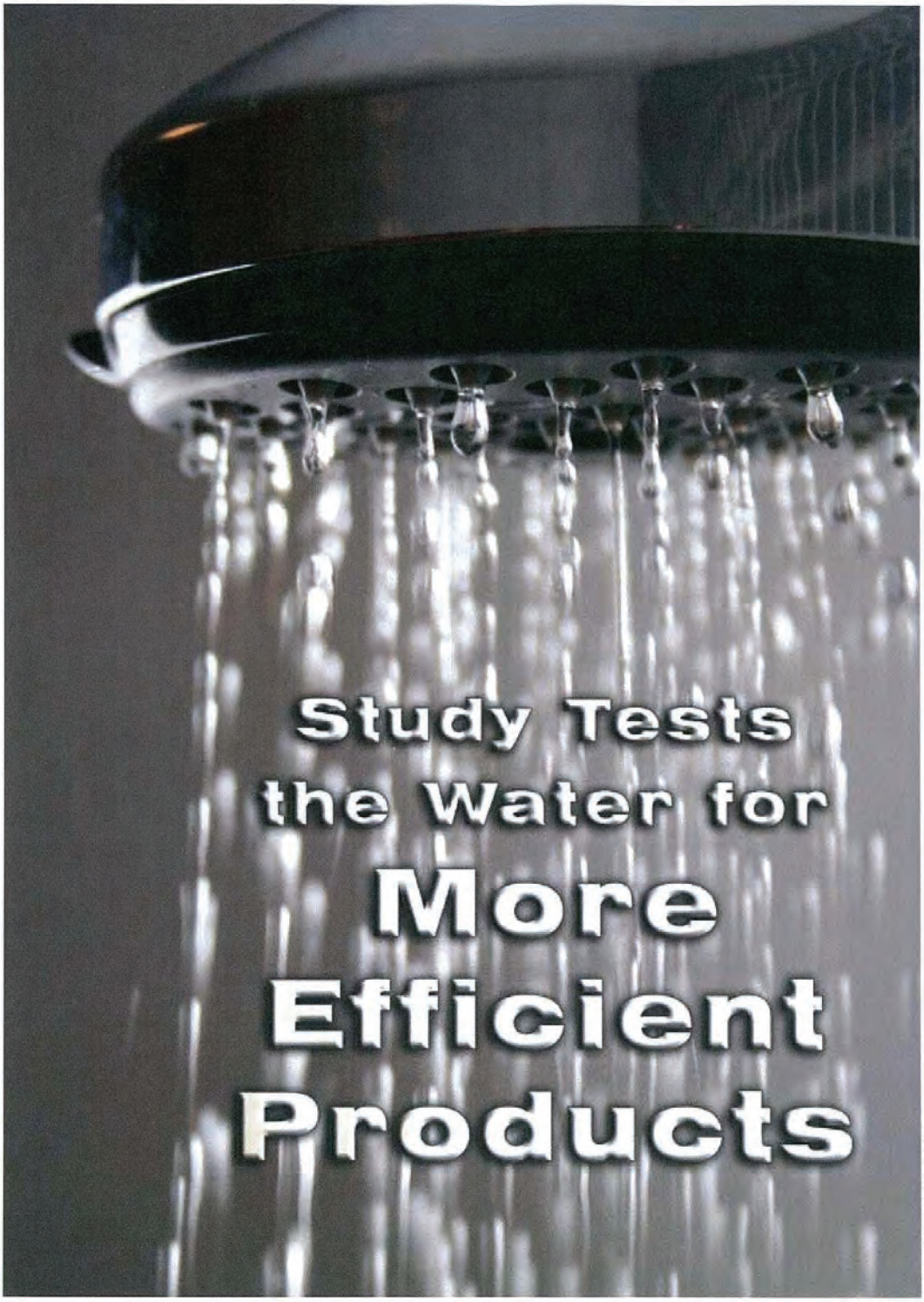
**During this LIFE SCIENCES lesson learners will look at the impacts of dams on organisms downstream, and whether it is necessary to have a dam to meet growing demands.**

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. If 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. | | | | | | |