EDUCATORS’ WORKSHOP MANUAL

Module 1

Pollution

Module 2

River Water Quality Monitoring
Learners record data on worksheets.

**VISION**
Research excellence for the sustainability of Africa’s aquatic environments.

**MISSION**
To be an interactive hub focused on serving the nation through generating, disseminating and applying knowledge to understanding and solving problems concerning the conservation and wise use of African aquatic biodiversity.
SEEING what they LOOK at: learners have a hands-on experience of their aquatic environment.
INTRODUCTION

The South African Institute for Aquatic Biodiversity (SAIAB) is a national research facility of the National Research Foundation. SAIAB runs an educational outreach programme through its Communications Division. This Educators’ Workshop Manual with modules on Pollution and River Water Quality Monitoring has been designed to support SAIAB’s environmental education outreach programmes. The aim of environmental education at SAIAB is:

To impact on values and attitudes of various publics through active engagement and to equip them with relevant information so they can take meaningful action that contributes towards the sustainable use of aquatic biodiversity.

PURPOSE

According to O’Donoghue (2001), “Learners also need to critically examine and question issues, and develop the insight and competence to make better environmental management and lifestyle choices”.

This learning programme affords learners in Grades 8 and 9 the opportunity to actively engage with and respond to local environmental issues through a variety of learning outcomes. The assessment standards encourage skills development in research work and community interaction (for example, through interviews, questionnaires, debates) which are central to this learning programme. The programme itself is not an end but a means to taking meaningful action on the issue of pollution now and in the near future.
## CURRICULUM LINKS

### MODULE 1: Pollution

<table>
<thead>
<tr>
<th>Learning Outcomes</th>
<th>Grade 8</th>
<th>Grade 9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Sciences</strong></td>
<td>Undersstands sustainable use of the earth's resources: Identifies information required to make judgements about resource use.</td>
<td>The learner: Understands sustainable use of the earth's resources: Responds appropriately to knowledge about the use of resources and environmental impact.</td>
</tr>
<tr>
<td><strong>Achievement is evident when learner, for example:</strong></td>
<td>• Plans and carries out an audit of all uses of water around the school premises, and develops an implementation plan to improve water management in the school.</td>
<td>• Organises an audit of water use, analyses data and prepares it for presentation in local newspaper or talk shows • Contributes to formulating a school environmental policy, including constructive ways to deal with waste material and to improve water management.</td>
</tr>
</tbody>
</table>

**Social Sciences**
The learner: • Identifies factors affecting selected social and environmental disputes including rights, gender, social, economic and political demands in a particular context.
MODULE 2: River water quality monitoring

Learning Outcomes

Grade 8

Natural Sciences
LO1: SCIENTIFIC INVESTIGATIONS:
The learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts.

Arts and Culture
LO2: REFLECTING:
The learner will be able to reflect critically and creatively on artistic and cultural processes, products and styles in past and present contexts.

Mathematics
LO5: DATA HANDLING
The learner will be able to collect, summarise, display and critically analyse data in order to draw conclusions and make predictions and to interpret and determine chance variation.

Assessment standards

Natural Sciences
The learner:
Conducts investigations and collects data: collects and records information as accurately as equipment permits and investigation purposes require. 
Achievement is evident when learner, for example:
• Sees the need to use measuring instruments, and does so with reasonable accuracy.
• Evaluates data and communicates findings: considers the extent to which the conclusions reached are reasonable answers to the focus question of the investigation.

Achievement is evident when learner, for example,
• Lists items of evidence supporting the findings;
• Describes how the plan and data collection procedure was checked against the focus question;
• Considers factors in the group which might have affected their results

Arts and Culture
The learner:
• Researcshes human rights and environmental issues and interprets these in small group role-plays.

Mathematics
The learner:
• Draws a variety of graphs by hand/technology to display and interpret data (grouped and ungrouped) including:
  • Bar graphs and double bar graphs;
  • Histograms with given intervals;
  • Pie charts;
  • Line and broken line graphs.
MODUL E 1: Pollution (littering)

The learning programme layout

The programme includes 6 learning units.

<table>
<thead>
<tr>
<th>Day</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introductory session at school</td>
</tr>
<tr>
<td>2 &amp; 3</td>
<td>Pollution investigation at school and home</td>
</tr>
<tr>
<td>4</td>
<td>Reporting and debate</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>Research news articles on littering in local paper</td>
</tr>
<tr>
<td>7</td>
<td>Oral presentations and discussions</td>
</tr>
<tr>
<td>8</td>
<td>National clean-up campaign / School clean-up campaign</td>
</tr>
</tbody>
</table>

**Activities:**

1. **Issue of focus - pollution (littering)**
   *Draw a mind map to establish prior knowledge about pollution in general*

2. **Enquiry encounters - school and home investigation**
   *Some of the important questions in the investigation:*
   - What do you like/dislike about your school grounds?
   - If there is any litter at the school, where does it come from?
   - What would you like to change at your school if anything?
   - Who is responsible for making those changes?
   - Would you sign a pledge to improve the outlook of the school grounds?
   - Why?
   Adapt same questions for the home investigation

3. **Enquiry encounters - research project**
   *Educator to assist learners to determine objectives (write a purpose statement), choose target group, prepare interview questions, make appointments, read about the institution to visit.*

4. **Information seeking - news articles in local newspapers about pollution levels in the communities, province, country**
   *Educator to assist learners to determine how, what and where to read.*

5. **Reporting - oral presentations, debate/discussions**
   *Learners to use various options of presenting information or findings: e.g. graphs, drama, posters, discussions, oral presentations, powerpoint presentations, poetry, debates.*

6. **Action taking - National Clean-up Campaign run by Department of Environmental Affairs and Tourism or a school clean-up campaign**
   *Action must address local environmental problems in a sustainable manner.*
Module 1: Pollution

Learning about pollution

Waiting to begin collecting

The challenge

What fun!

After the clean-up

Cleaning up the beach

Successful pollution collectors

Collected litter
CLEAN-UP CAMPAIGN

QUESTIONNAIRE

Section 1: Clean-up campaign

<table>
<thead>
<tr>
<th>NO</th>
<th>QUESTION</th>
<th>YES/NO</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you find much pollution in the river streams or in your surroundings?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>What were the most common items seen or collected?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>What do you think of the clean up campaign?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Section 2: Rubbish collection

| 1  | Who is responsible for collecting rubbish in your area?                    |        |         |
| 2  | How often is rubbish collected in your area?                              |        |         |
| 3  | Are you happy with the way rubbish is handled/collected?                  |        |         |
| 4  | If yes/no to the above, explain                                           |        |         |

Section 3: General

| 1  | How would you rate pollution levels in your town generally?               | Too much | Reasonable | Not much |
| 2  | What are the main causes of pollution in your area?                       |          |           |
| 3  | What do you think your role is as a resident?                             |          |           |

Section 4: Action

| 1  | Is there any action needed? Explain your answer?                           |        |         |
| 2  | If yes, what exactly would you like to be done?                            |        |         |
| 3  | Would you participate in follow-up clean-up campaigns and/or community driven initiatives to improve the situation? |        |         |
| 5  | If yes to the above question, please provide contact details.              | Name:   | School: |
|    |                                                                          | Grade:  | Contact number: |
Module 1: Pollution

Aquatic animals die from pollution

Sampling in the river

Identifying organisms collected

Rubbish polluting the river
A workshop facilitator explains details to fascinated group of learners.
Module 2: River Water Quality Monitoring

Why investigate the following criteria?

1. **Pollution**
   The amount of litter generated from catchment areas can directly impact on the life of rivers or streams. Visible pollution is a one of the indicators of the condition of the river or stream.

2. **Invertebrates**
   These are living organisms that give an indication of the health of river water. Some animals and plants are very sensitive to pollution and will not survive in polluted water. Others can tolerate (put up with) quite a lot of pollution. By observing which animals and plants live in the river we can tell how polluted the water is. The “water slide”, which is a rough pollution indicator using water organisms, is used to interpret the condition of the water.

3. **Temperature, Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)**
   Temperature changes in the water influence the type, nature and number of animals that live in that water. Changes in temperature also cause organisms to migrate to preferred areas where the temperature gradient is acceptable. A high temperature could be the reason why very few or no organisms are found.

   Water contains dissolved oxygen and animals that live in the water use this oxygen. Much of the dissolved oxygen in water comes from the atmosphere. Algae and rooted plants also deliver oxygen to water through photosynthesis. The percentage saturation of dissolved oxygen is an important measurement of water quality.

   High levels of bacteria from sewage pollution or large amounts of rotting plants can cause the percentage of dissolved oxygen to decrease.

   When aquatic plants die, they are fed upon by bacteria. In the process of breaking down the organic matter the bacteria use up oxygen. The measure of the quantity of dissolved oxygen used is called Biochemical Oxygen Demand (BOD)

4. **pH**
   Plants and animals living in water can tolerate certain ranges of pH. Natural river water pH is neutral (pH7) or slightly acidic (pH6-7). Pollution in the air causes rainwater to become acidic. Car exhaust fumes and factory smoke in the air causes acid rain which collects in the rivers and can also burn trees and crops. The rocks and soil in the catchment area and on the banks of the river can be acidic or alkaline. Sewage and industrial waste also affect the pH of the river.

5. **Nitrate and Nitrite levels**
   Nitrates and nitrites are chemical nutrients that may contribute to the problem of poor water quality. They enter into water bodies primarily through sewage discharge or fertilizer run-off from farmlands. The presence of nitrates in a water system can lead to excessive algae (green water)
or above average growth of aquatic plants. In humans, excessive nitrates, when consumed in water, have the potential to cause tiredness and failure to thrive.

**Coliform bacteria levels**
Coliform bacteria are found in the intestines of most animals and humans. Coliform bacteria are also present in the soil. The presence of coliforms might suggest that the water has been contaminated with faeces. Coliform bacteria can enter rivers through direct contamination from humans and animals, from agricultural and storm water runoff carrying wastes and from human sewage discharged into the water. A person swimming in such water has a greater chance of contracting diseases or illness such as typhoid fever, hepatitis and ear infections.

**Turbidity**
Testing the turbidity of the water involves finding out whether the water is clear or muddy. Turbidity is caused by the presence of suspended solid matter in water. High turbidity in water may be caused through soil erosion, urban runoff or the presence of bottom feeders that stir up sediment or algal growth. At higher levels of turbidity, water could lose its ability to support aquatic life because the solid particles block out the sunlight. Turbidity can thus affect water, photosynthesis and oxygen content in the water. Suspended solids can also clog fish gills and suffocate the eggs of fish and aquatic insects.
Module 2: River Water Quality Monitoring

**Temperature, Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)**

**Nitrate and Nitrite levels**

**Coliform bacteria levels**

**Turbidity**

**Invertebrates:**
- glove, magnifying glass
- and the water slide

**POLLUTION!**

Some tools for monitoring water quality

**White tray**

**WATER QUALITY SLIDE**

As the level of pollution increases so the variety of animals decreases.

**Invertebrates:**
- Mayfly nymphs
- Dragonfly nymphs
- Water boatman
- Water scorpion
- Long-bodied esche
d- Snail
- Caddisfly larva
- Red-tailed maggot
- Flatworm (planaria)
- Whirligig beetle
- Water snail

**PH Test**

**Nitrate and Nitrite levels**

**Coliform bacteria levels**

**Turbidity**
**DATA RECORDING SHEETS**
Adapted from the Somerset Educational Micro-life Water Quality Testing Kit

1. **DATA RECORDING SHEET: Pollution**

**GROUP:** ………………………………………………………………………………………………………………………………

**LEARNER NAME:** …………………………………………………………………………………………………………………

**Resources:** Clipboard, pen/pencil, paper

Use your senses to see and smell if the water is polluted. **DO NOT DRINK THE WATER.**

**Answer the following questions:**

1. What is the colour of the water and what does it smell like?

2. Are there any obvious signs that the water is polluted with solid waste? If yes, list the items.

3. Do you think that people wash or bathe here? Why?

4. Are there any dead animals in the water (fish, frogs, birds, etc)?

5. Is there excessive plant growth (macrophytes) or algae (microphytes) in the water?

6. Do you see any signs of soil erosion (muddy water)?

7. Using your answers to the questions asked, which of the blocks below best describes the water? Choose ONE.

   - VERY POLLUTED
   - SLIGHTLY POLLUTED
   - NOT AT ALL POLLUTED
2. **DATA RECORDING SHEET:** Macro-invertebrate count

**GROUP:** ..................................................... **LEARNER NAME:** .................................................................

**Resources:** Clipboard, pen/pencil, A4 blank paper, fine-meshed net (e.g. stocking), white trays, magnifying glass, plastic container, water life identification sheet, water quality slide.

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<table>
<thead>
<tr>
<th>Invertebrate group</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snails</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flatworms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leeches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundworms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sludge worms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayfly nymphs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damselfly and dragonfly nymphs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stonefly nymphs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquatic bugs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caddisfly larvae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquatic beetles and their larvae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquatic fly larvae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshwater crabs and shrimps</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Water Life Identification Sheet

Snails
Flatworms (Planaria)
Leech
Roundworms (Nematodes)
Sludge worm
Mayfly nymphs
Damsel and dragonfly nymphs
Stonefly nymphs
Aquatic bugs
Caddisfly larvae
Aquatic beetles and their larvae
Aquatic fly larvae
Freshwater crabs and shrimps
A. Record the temperature of the water at the same spot where you are going to collect your sample of water as follows:
1. Hold the thermometer 10cm below the water surface for two minutes
2. Remove the thermometer from the water, read the temperature and record the temperature as degrees Celsius.
3. NB: first take the temperature reading near shore, the second one a little deeper in the water.

B. Choose one of the small tubes and a stopper to take a water sample for Dissolved Oxygen
1. Holding the tube in your hand place it in the water about 10cms below the surface at the same place where you measured the temperature.
2. Carefully remove the tube from the water, keeping the tube full to the top.
3. Drop two Dissolved Oxygen (DO) Test tabs into the tube.
4. Push the plastic cork into the tube until it fits tightly. More water will overflow as the cork is pushed in. There should be no air bubbles in the sample.
5. Shake the tube over and over for about 4 minutes until the tablets have dissolved.
6. Wait 5 minutes to allow colour to develop.
7. Compare the colour of the sample to that on the Dissolved Oxygen colour chart. Record the result as “ppm Dissolved Oxygen”.
8. Find your temperature result of the water sample on the % saturation chart. Find your Dissolved Oxygen result of the water sample at the top of the chart.
9. The % saturation of the water tested will be indicated where the temperature row and Dissolved Oxygen column intersect. Record the result in the table.

C. Choose one of the small tubes and a stopper to take a water sample for Biochemical Oxygen Demand (BOD)
1. Submerge the small tube into the water sample. Carefully remove the tube, keeping the tube full to the top. Cap the tube.
2. Wrap the tube with aluminium foil, store it in a dark place at room temperature for 5 days.
3. Unwrap the tube. Add two Dissolved Oxygen test tablets to the test tube.
4. Cap the tube. Shake over and over until tablets have dissolved. Wait 5 minutes.
5. Compare the colour of the sample to the Dissolved Oxygen colour chart. The difference in the Dissolved Oxygen level between the uncovered tube in the previous test and the covered tube is the Biochemical Oxygen Demand.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Temperature °C</th>
<th>Dissolved Oxygen (DO) ppm</th>
<th>Biochemical Oxygen Demand (BOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NB: Wait for 5 days for results
4.1 DATA RECORDING SHEET: pH

GROUP: .................................................. LEARNER NAME: .................................................................

Resources: Clipboard, pen/pencil, A4 blank paper, pH test strip, pH colour chart, nitrate/nitrite colour indicator strip.

Method

1. Hold the pH test strip between your index finger and thumb.
2. Dip the test strip into the water to be tested.
3. Hold the test strip under water for about 10 seconds until it changes colour.
4. Shake off excess water and match the colours on the strip to the colour chart for pH.
5. Record the pH below.

<table>
<thead>
<tr>
<th>pH: site 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH: site 2</td>
</tr>
<tr>
<td>pH: site 3</td>
</tr>
</tbody>
</table>

4.2 DATA RECORDING SHEET: Nitrates and Nitrites

Method

1. Dip the nitrate/nitrite indicator strip in the water so that both pads are immersed and hold for 2-3 seconds.
2. Shake off excess water and wait for 1 minute before taking a reading.
3. Compare the colours of the indicator pads on the stick with those on the chart.
4. Record your results in the table below.

<table>
<thead>
<tr>
<th>Site</th>
<th>Nitrate</th>
<th>Nitrite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Module 2: River Water Quality Monitoring

5.1 DATA RECORDING SHEET: Coliform

Method

1. Using a sterile pipette draw up a sample of water and add it to one of the large test tubes containing a tablet. Repeat this until the tube is filled to the 10ml line (second line).
2. Replace the cap on the test tube. **Do not shake the tube.**
3. Stand the tube upright, with the tablet flat on the bottom of the tube.
4. Incubate at room temperature, out of direct sunlight for 44 – 48 hours. Store the tubes between 21°C to 27°C. Do not disturb, handle or shake tubes during the incubation period.
5. Compare the picture of the tube to the picture on the Coliform colour chart. Record the results as negative or positive.

<table>
<thead>
<tr>
<th>Coliform: site 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coliform: site 2</td>
<td></td>
</tr>
<tr>
<td>Coliform: site 3</td>
<td></td>
</tr>
</tbody>
</table>

5.2 DATA RECORDING SHEET: Turbidity

Method

1. Hold the lid in your hand at least 20cm below the surface of the water.
2. Look at the turbidity disk through the water. Which numbers are visible?
3. Record your findings using the table below to as a reference.

<table>
<thead>
<tr>
<th>Which numbers are visible?</th>
<th>5,4,3,2</th>
<th>4,3,2</th>
<th>3,2</th>
<th>2/none</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Turbidity</td>
<td>≤ 10 NTU</td>
<td>10-20 NTU</td>
<td>20-30 NTU</td>
<td>≥30 NTU</td>
</tr>
<tr>
<td>Turbidity (NTU) : site 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity (NTU) : site 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity (NTU) : site 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GROUP: .................................. LEARNER NAME: .................................................................

Resources: Clipboard, pen/pencil, A4 blank paper, sterile pipette, tablets, test tube, Coliform colour chart, lid with turbidity disk.
WATER QUALITY AUDIT QUESTIONS

1. Water life as indicator of river health status: Macro-invertebrates

1.1 Which are the most common group of animals?

1.2 Which are the least common?

1.3 What is the result on the water quality slide at each site?

1.4 Which site is the most polluted?

2. Dissolved oxygen (DO) and Biochemical Oxygen demand (BOD)

2.1 Which site has the lowest DO?

2.2 What could be the cause of this?

2.3 Which site has the highest BOD?

2.4 What could be the cause of this?
3. pH and Nitrates/Nitrites

3.1 At the three different sites, is the water neutral, slightly acidic or slightly alkaline?

<table>
<thead>
<tr>
<th></th>
<th>Neutral</th>
<th>Slightly acidic</th>
<th>Slightly alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2 Are nitrates present in the water?

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.3 Where do you think the nitrates found in the water come from?

.......................................................................................................................

.......................................................................................................................

4. Coliform and turbidity

4.1 Are the results on the coliform colour chart negative or positive?

.......................................................................................................................

4.2 What does a negative result indicate?

.......................................................................................................................

4.3 What does a positive result indicate?

.......................................................................................................................

4.4 Which site has the highest turbidity, and why is this the case?

......................................................................................................................
Notes:

References and Acknowledgements

- SOMERSET EDUCATIONAL (Pty) LTD: Microlife Water Quality Testing Kit
- Catchment Action Manual, Share-Net
- O’Donoghue (2001)

Personal communication with:
- Ms Ingrid Schudel: Rhodes University Environmental Education and Sustainability Unit
- Department of Education, Curriculum and management, Grahamstown District