The Integration of Aquatic Toxicity Tests with South African Water Use Licence Authorization Legislation

Introduction
The current use of Toxicity Tests within Water Use Licenses and suggested way forward

Hesmarie Pearson
The South African National Water Act (Act 36 of 1998) mandate:

- The establishment of national monitoring systems to reduce and prevent degradation of water resources and to assess their quality
Introduction

- Form this it is clear that managing complex wastewater discharges or effluents presents numerous challenges to government and industry.
- For the past decades the Department of Water Affairs (DWA) has controlled water pollution by managing the levels of single substances/chemicals in water.
- This traditional physical-chemical approach is based on well known standards and compliance limits.
Illustration of physical-chemical approach

- However, experience has shown that this physical-chemical approach are not fully able to assess the ecological and toxicological hazards that may be posed by complex effluents.

  e.g. complex wastewater is like mixing different color paints (chemicals) in different volumes.
Limitations to the physical-chemical approach include:

- Restriction to analyses of the known chemicals/compounds.
  - "Not looked for"
- Complex interaction or bio-availability of the contaminants.
  - "Over or under estimation of real danger"
Example of physical-chemical results
Effect based approach

- To protect aquatic ecosystems that receive complex effluents it is necessary to focus on potential effects of these effluents and not only the chemicals themselves.
So……

- Toxicity tests:
  Investigate “the effect”

- Physical-chemical analysis:
  Investigate “the cause”

Why look for causes, if there are no effects...?
“Driepootpot approach”

The three legs of the “DRIEPOOTPOT” consists of the:

- Toxicity tests.
- Field indexes.
  (e.g. SASS)
- Chemical tests.
A crucial implication of the National Water Act (Act 36 of 1998) is that an ecological effect-based approach needs to be applied to water resource management, thus supporting regular toxicity testing of water resources as well as complex industrial waste waters (effluents) which are released into these water resources.

Aquatic toxicity testing in South Africa: Status of Aquatic Toxicity Testing in South Africa, 2011 (WRC report number: 1853/1/11)
To comply with the ecological effect based requirements the following two programs were designed by DWA:

- **Complex industrial wastewaters**

- **Water resources**
International use of toxicity tests

- The application of this effect based approach using standardised toxicity test protocols in the assessment of complex industrial wastes for compliance and regulatory monitoring have led to routine toxicity testing in many countries.
International regulation and legislation

- **USA** - Includes acute and chronic toxicity tests in discharge permits (Clean Water Act, 1977; Water Quality Act, 1987 and National Pollutant Discharge Elimination System).

- **Canada** - Canadian Environmental Protection Act, 1987 demands use of toxicity tests for compliance monitoring & hazard assessment. Environmental Protection Service Laboratory perform numerous toxicity tests since 1980’s.


- **Ireland** – Discharge guidelines are in industry specific permits.

- **UK** – Biological monitoring program of point source discharge.

- **Netherlands** – Include various toxicity tests in legal and regulatory measures.

- **Italy** – Use *Daphnia* lethality test since 2003.

Toxicity tests used internationally

- **USA** – acute and chronic toxicity tests.
  - Use various plant, invertebrate and vertebrate species as test organisms.
- **Canada** – determine acute lethal toxicity via “Best Available Technology Economically Achievable”.
  - 96h rainbow trout and *Daphnia* test.
  - Chronic, genotoxic and sub-lethal effects.
- **France** – Biological toxicity test
  - 24h *Daphnia magna* test.
  - Zebra fish and rainbow trout (OECD, 1984).
- **Germany** – Standard methods, DIN 1989b.
  - *Daphnia, fish, algal and luminescent bacteria test.*
- **Ireland** – Annually or bi-annually.
- **UK** – Biological monitoring.
  - Three taxonomic groups: fish, invertebrates and algae.

International compliance limits

- Internationally toxicity limits are set by the regulatory authorities and are used in the same manner that chemical limits are used.
  - **USA** - To protect aquatic life the ambient effluent (in-stream) toxicity should not exceed 1.0 TUc (chronic) or 0.3 TUa (acute) to most sensitive of at least three different test species.
  - **Canada** - Industrial and municipal discharge must be non-acutely lethal to fish.
  - **Germany** - Based on dilution factor.
  - **France** - Maximum dilution necessary to bring the effluent below lethal dose.
  - **Ireland** - Requires a dilution factor of at least 20 for each toxic unit discharged.

Progress in South Africa

- **1991** - DWAF acknowledged toxicity tests as a control parameter for hazardous discharges.
- **1993** - Extensive evaluation of established toxicity tests at DWA.
- **1998** - Aquatox Forum was established.
- **1999** - South Africa host ISTA9 in Pretoria.
- **2003** - DWAF published “the Direct Estimation of Ecological Effect Potential (DEEEP) approach” for the management of complex wastewater.
- **2005** - Toxicity tests are included inscribed in a number of wastewater licenses, as part of monitoring programs.
- **2006** - Completion of design and implementation plan for National Toxicity Monitoring Programme.
- **2011** - Inclusion of toxicity tests in Green drop handbook, version1.
- **2013** - South Africa will be hosting ISTA16 in Cape Town.
Aquatox Forum background

- The Aquatox Forum was formed on 14 January 1998 by a group of approximately 10 scientists with a common interest in water toxicity testing.
- Was legalized as a non-profit organisation on 11 February 2005.
- Currently 60 members (20 corporate members).

Vision

To serve as platform for the advancement of water toxicity testing in South Africa.

http://aquatoxforum.com/
Aquatox Forum objectives

- To pro-actively assist legislators and regulators to formulate and implement credible toxicity test requirements.
- To drive the standardization of toxicity tests in collaboration with an acceptable standardization body.
- To establish a network for communication, liaison and information sharing between water toxicologists, regulating authorities, the public sector and industry (nationally and internationally).
- To assist in the promotion, publication and implementation of toxicity tests.
- To assist and advise in the training and education of interested and affected parties.
- To assist in the identification and formulation of viable and necessary research.
- To adopt and prescribe a code of conduct for its members that is in line with the best practice and professional ethics.
WRC projects

- **Standardisation of methods**
  - “Methods Manual”

- **Guideline for accreditation in toxicity laboratories**

- **Current status in SA**

- **Establish compliance limits for water use licences**
Direct Estimation of the Ecological Effect Potential (DEEEEP) approach

- DWAF published the Direct Estimation of Ecological Effect Potential (DEEEEP) approach for the management of complex wastewater discharges, 2003 and has been implementing it since 2005 in water use licences.

- Copy available on DWA webpage
Current licences

“monthly toxicity tests at the specified monitoring points”.

OR

The licensee shall participate in any initiative such as Direct Estimation of Ecological Effect Potential (DEEEP) to determine the toxicity of complex tailings waste discharges. Both acute and chronic toxicity must be addressed and at least three taxonomic groups must be present when toxicity tests are performed.
Recommended licence conditions

- Monitoring points.
- Monitoring frequency.
- Tests.
- Compliance limits.
- Reporting.
Monitoring points

- Samples for toxicity tests should be collected from the following sampling points:
  - at the final outflow/discharge,
  - upstream (within 5 km radius),
  - downstream (within 5 km radius of discharge) and/or
  - downstream (within 20 km radius where applicable) from the final outflow.
Sampling frequency

- Monthly.
- Bi-monthly.
- Quarterly (seasonal variability).
- Six monthly.
- Annually.
Schematic diagram of the tests prescribed in the DEEEP approach

Biochemical/chemical oxygen demand
(COD<200mg/l or BOD<50mg/l)

↓

Acute toxicity tests
(Suggested battery of tests include: bacteria, algae, invertebrates and vertebrates)

↓

Chronic toxicity tests

↓

Mutagenicity tests

↓

Bioaccumulation

↓

NO HAZARD
(General Authorization)
Biochemical/chemical oxygen demand (COD and/or BOD tests)

- Initial COD and/or BOD tests will be conducted.
  - Compliance limits for COD and/or BOD tests conducted:
    - 200 mg/l for COD
    - 50 mg/l for BOD.
  - When compliance limits for above are met continue with acute toxicity tests.
## COD and BOD compliance limits

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Hazard description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical Oxygen Demand (COD)</strong></td>
<td>COD $\leq$ 200 mg/l</td>
<td>Acceptable</td>
</tr>
<tr>
<td></td>
<td>COD $\geq$ 200 mg/l</td>
<td>Unacceptable</td>
</tr>
<tr>
<td><strong>Biological Oxygen Demand (BOD)</strong></td>
<td>BOD $\leq$ 50 mg/l</td>
<td>Acceptable</td>
</tr>
<tr>
<td></td>
<td>BOD $\geq$ 50 mg/l</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>
Acute toxicity tests

- Recommend to perform acute toxicity tests representing at least three of the four trophic levels.

<table>
<thead>
<tr>
<th>Trophic level</th>
<th>Toxicity tests to be performed*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td><em>Vibrio fischeri</em> bioluminescent bacteria test (e.g. ISO 11348-3, 2007).</td>
</tr>
<tr>
<td>Algae</td>
<td>Growth Inhibition Test Using a Freshwater Alga (e.g. Environment Canada, 2007).</td>
</tr>
<tr>
<td>Invertebrates</td>
<td><em>Daphnia pulex and/or Daphnia magna</em> acute toxicity test (e.g. US EPA, 2002).</td>
</tr>
<tr>
<td>Vertebrates</td>
<td><em>Poecilia reticulata or Danio rerio</em> fish acute toxicity test (e.g. OECD, 1992).</td>
</tr>
</tbody>
</table>

* The toxicity tests listed are taken from the DEEEP protocol and the NTMP (Jooste and Herbst 2003.)
Quality assurance

- Laboratory must preferably use internationally recognised standard methods or methods from the “Methods Manual” (Slabbert, 2004).

- Accredited laboratories SANS 17025, 2005 (where possible).

OR

- Must participate in Proficiency Scheme.
# ISO 17025 Accredited Toxicity Testing Laboratories

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Location</th>
<th>SANAS number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golder Associates Research Laboratory – Aquatic Toxicity Division</td>
<td>Johannesburg</td>
<td>T0384</td>
</tr>
<tr>
<td>Rand Water – Analytical Services</td>
<td>Vereeniging</td>
<td>T0046</td>
</tr>
<tr>
<td>DWA – Resource Quality Services</td>
<td>Pretoria</td>
<td>T0073</td>
</tr>
<tr>
<td>Umgeni Water – Analytical Services</td>
<td>Pietermaritzburg</td>
<td>T0036</td>
</tr>
<tr>
<td>eThekweni Water &amp; Sanitation - Scientific Services</td>
<td>Durban</td>
<td>T0372</td>
</tr>
</tbody>
</table>
# Other Toxicity Testing Laboratories

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renaissance Environmental Hub</td>
<td>VanderBijl Park</td>
</tr>
<tr>
<td>Vaal University of Technology, Ambio</td>
<td>VanderBijl Park</td>
</tr>
<tr>
<td>SASOL Technology R &amp; D</td>
<td>Sasolburg</td>
</tr>
<tr>
<td>SASOL Technology R &amp; D</td>
<td>Secunda</td>
</tr>
<tr>
<td>Cleanstream Biological Services</td>
<td>Pretoria</td>
</tr>
<tr>
<td>University of Pretoria</td>
<td>Pretoria</td>
</tr>
<tr>
<td>CSIR</td>
<td>Pretoria</td>
</tr>
<tr>
<td>Improchem</td>
<td>Johannesburg</td>
</tr>
<tr>
<td>University of Johannesburg</td>
<td>Johannesburg</td>
</tr>
<tr>
<td>Johannesburg Water</td>
<td>Johannesburg</td>
</tr>
<tr>
<td>Buckman Laboratories</td>
<td>Johannesburg</td>
</tr>
<tr>
<td>Highveld Biological</td>
<td>Johannesburg</td>
</tr>
<tr>
<td>ToxSolutions, Kits and Services</td>
<td>Johannesburg</td>
</tr>
</tbody>
</table>
## Other Toxicity Testing Laboratories

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Potchefstroom</td>
<td>Potchefstroom</td>
</tr>
<tr>
<td>University of the Orange Free State</td>
<td>Bloemfontein</td>
</tr>
<tr>
<td>CSIR</td>
<td>Durban</td>
</tr>
<tr>
<td>University of the Western Cape</td>
<td>Cape Town</td>
</tr>
<tr>
<td>City of Cape Town</td>
<td>Cape Town</td>
</tr>
<tr>
<td>University of Stellenbosch</td>
<td>Stellenbosch</td>
</tr>
<tr>
<td>George Municipality</td>
<td>George</td>
</tr>
<tr>
<td>Rhodes University – Unilever Centre for Environmental Water Quality</td>
<td>Grahams Town</td>
</tr>
<tr>
<td>Rhodes University - Institute for Water Research</td>
<td>Grahams Town</td>
</tr>
<tr>
<td>City of Windhoek</td>
<td>Windhoek</td>
</tr>
<tr>
<td>University of Namibia</td>
<td>Windhoek</td>
</tr>
</tbody>
</table>
## Acute toxicity test types

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Screening test</strong></td>
<td>No sample dilution (100% sample is exposed to test organisms)</td>
<td>Identify effect</td>
</tr>
<tr>
<td><strong>Definitive test</strong></td>
<td>Sample dilution series (e.g. 100%, 50%, 25%, 12.5% and 6.25% of the sample is exposed to test organisms)</td>
<td>Quantify effect</td>
</tr>
</tbody>
</table>

- Start monitoring program with screening tests.
- If results indicate more than 50% mortality/inhibition continue with definitive tests.
Data treatment – screening tests

- Report the screening test endpoints.
  - % effects, such as mortality or % growth inhibition or stimulation

YOU HAVE A PROBLEM

- Do a definitive test if the screening test results exceed 50% mortality or % growth inhibition.

- Growth stimulation does not indicate toxic effect.
Data treatment – definitive tests

- Report the definitive test endpoints.
  - LC/EC$_{50}$ values

- The toxicity of toxicants/effluents are described in terms of the dose that causes a particular effect in a specified population.

HOW BIG IS YOUR PROBLEM
Toxicity Units

- Toxicity and effective concentration (ECs) reported are inversely related.
  - The lower the EC, the higher the toxicity.
- In order to minimise the confusion that is caused by the foregoing inverse relationship, Toxicity Units (TUs) are used to describe concentration-based toxicity measurements.
  
  \[ \text{TU}_a = \frac{100}{\text{EC}_{50} \text{ or } \text{LC}_{50}} \]

- TU represent single test result.
Toxicity units classification

- Do acute toxicity screening test.
- If results indicate more than 50% mortality or inhibition continue with definitive tests and determine LC/EC_{50} value.
- Calculate toxicity units (TU_{a} = 100/LC or EC_{50}).
- Classify individual test result (compare to criteria, based on Tonks & Baltus, 1997).

<table>
<thead>
<tr>
<th>toxicity units TUs</th>
<th>classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Limited to not acutely toxic</td>
</tr>
<tr>
<td>1-2</td>
<td>Negligibly acutely toxic</td>
</tr>
<tr>
<td>2-10</td>
<td>Mildly acutely toxic</td>
</tr>
<tr>
<td>10-100</td>
<td>Acutely toxic</td>
</tr>
<tr>
<td>&gt;100</td>
<td>Highly acutely toxic</td>
</tr>
</tbody>
</table>

- Toxicity units TUs are typically used in wastewater discharge permits.
Hazard classification system – Option 1

- Classify battery of test results using the following Hazard Classification System index for definitive tests by using most sensitive test species:

**Class I: No acute toxicity**
None of the tests shows a toxic effect

**Class II: Slight acute toxicity**
Effect percentage observed in one toxicity test is significantly higher than in the control, but is below 50\% (<1TU)

**Class III: Acute toxicity**
The L(E)C50 is reached or exceeded in at least one test, but in the 10-fold dilution of the sample the effect is lower than 50\% (1-10 TU)

**Class IV: High acute toxicity**
The L(E)C50 is reached in the 10-fold dilution for at least one test, but not in the 100-fold dilution (10-100 TU)

**Class V: Very high acute toxicity**
The L(E)C50 is reached in the 100-fold dilution for at least one test (>100 TU)

*Based on Persoone et al, 2005*
## Practical example

<table>
<thead>
<tr>
<th>Test</th>
<th>TU</th>
<th>Test score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Micro-algae</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Protozoa</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>Rotifers</td>
<td>55</td>
<td>3</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>27</td>
<td>3</td>
</tr>
</tbody>
</table>

### Classification:
- The concerned wastewater sample is classified in class IV (high acute toxicity) since the number of TU in the most sensitive test is situated between 10 and 100.

- Class weight score: $\frac{3 + 2 + 1 + 3 + 3}{5} = \frac{12}{5} = 2.4$
- Class weight score (in %): $\frac{2.4 \times 100}{3} = 80\%$
Hazard classification system – Option 2

- The hazard assessment criterion described by Persoone et al. (2003) and Ansara-Ross et al. (2010) was adapted for the DEEEP approach.
- Once the effect for each test was determined, the individual result was given a “weighted hazard score” (WHS).
- A cumulative “weight hazard score (WHS)” for all tests was then calculated for each sample by summation of the individual weighted hazard scores.
- A “Hazard Assement category” for each site/sample was subsequently given to the cumulative WHS.
- The scoring system comprises of six ranking classes ranged from, “not acutely hazardous or toxic” to “extremely acutely hazardous or toxic”.
- This hazard category can then be assessed in terms of ecological management.
# Weighted hazard score

<table>
<thead>
<tr>
<th>Test</th>
<th>Screening test result</th>
<th>Definitive test (toxicity unit, TUa*)</th>
<th>Hazard description</th>
<th>Weighted hazard score per test (WHS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteria</strong> <em>(Vibrio fischeri)</em></td>
<td>≤ 20%</td>
<td>≤ 0.4</td>
<td>No stimulation or inhibition</td>
<td>0</td>
</tr>
<tr>
<td>21-35%</td>
<td>0.41-0.99</td>
<td>Slight stimulation or inhibition</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>36-50%</td>
<td>1-9.99</td>
<td>Moderate stimulation or inhibition</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>51-75%</td>
<td>10-49.99</td>
<td>High stimulation or inhibition</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>76-100%</td>
<td>50-99.99</td>
<td>Very high stimulation or inhibition</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>&gt;100%</td>
<td>≥100</td>
<td>Extremely high stimulation or inhibition</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Algae</strong> <em>(Selenastrum capricornutum)</em></td>
<td>≤ 20%</td>
<td>≤ 0.4</td>
<td>No stimulation or inhibition</td>
<td>0</td>
</tr>
<tr>
<td>21-35%</td>
<td>0.41-0.99</td>
<td>Slight stimulation or inhibition</td>
<td>1</td>
<td></td>
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<td>Very high stimulation or inhibition</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>&gt;100%</td>
<td>≥100</td>
<td>Extremely high stimulation or inhibition</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Water flea</strong> <em>(Daphnia pulex or Daphnia magna)</em></td>
<td>≤ 10%</td>
<td>≤ 0.4</td>
<td>No acute toxic effect</td>
<td>0</td>
</tr>
<tr>
<td>11-35%</td>
<td>0.41-0.99</td>
<td>Slight acute toxic effect</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>36-50%</td>
<td>1-9.99</td>
<td>Moderate acute toxic effect</td>
<td>2</td>
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<td>Very high acute toxic effect</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>≥100</td>
<td>Extremely high acute toxic effect</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

*TUa is an acute toxic unit and is derived from calculation in an acute toxicity test. For a discharge the TUa = 100/EC50 or LC50.*
## Hazard assessment categories

<table>
<thead>
<tr>
<th>Hazard category</th>
<th>Hazard description</th>
<th>Result</th>
<th>Cumulative hazard score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Natural)</td>
<td>No hazard due to toxicity</td>
<td>None of the test show a toxic effect</td>
<td>0</td>
</tr>
<tr>
<td>B (Fair)</td>
<td>Slight hazard due to toxicity</td>
<td>The cumulative hazard score of one of the toxicity tests was 1</td>
<td>1</td>
</tr>
<tr>
<td>C (Good)</td>
<td>Moderate hazard due to toxicity</td>
<td>The cumulative hazard score of one or more of the toxicity tests was between 2 and 5</td>
<td>2-5</td>
</tr>
<tr>
<td>D (Poor)</td>
<td>High hazard due to toxicity</td>
<td>The cumulative hazard score of one or more of the toxicity tests was between 6 and 10</td>
<td>6-10</td>
</tr>
<tr>
<td>E (Very poor)</td>
<td>Extreme hazard due to toxicity</td>
<td>The cumulative hazard score of one or more of the toxicity tests was greater than 10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>F (Extremely poor)</td>
<td>Extreme hazard due to toxicity</td>
<td>The cumulative hazard score of one or more of the toxicity tests was greater than 15</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>
Test report

The test report shall include the following information:

Customer’s details.
- Analyses requested by (company).
- Contact person (name and designation).
- Postal address.
- Telephone number.
- Fax number.
- Cell number.
- E-mail address.
- Order number.

Licence/permit number
- Toxicity testing requirements of licence/permit.
- Plant location.
- Name of receiving water body (up and downstream of effluent discharge).
- Sub-contractor (if sub-contracted).
  - Name of firm.
  - Phone number.
  - Address.
- Objective of test

Plant operations
- Product(s)
- Raw materials
- Operating schedule
- Description of waste treatment
- Schematic of waste treatment
- Retention time (if applicable)
- Volume of discharge
- Design flow of treatment facility at time of sampling
# Test report

<table>
<thead>
<tr>
<th>Sample type (effluent/receiving water/dilution water/product)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effluent samples</strong></td>
</tr>
<tr>
<td>○ Sampling point (including latitude and longitude).</td>
</tr>
<tr>
<td>○ Sample collection method and sample container description.</td>
</tr>
<tr>
<td>○ Collection dates and times.</td>
</tr>
<tr>
<td>○ Sampler name.</td>
</tr>
<tr>
<td>○ Was the sample(s) transported in a cooler box? Yes/No</td>
</tr>
<tr>
<td>○ Mean daily discharge on sample collection date.</td>
</tr>
<tr>
<td>○ Lapsed time from sample collection to delivery.</td>
</tr>
<tr>
<td>○ Sample temperature when received at the laboratory.</td>
</tr>
<tr>
<td>○ Physical and chemical data.</td>
</tr>
<tr>
<td><strong>Receiving water samples</strong></td>
</tr>
<tr>
<td>○ Sampling point (including latitude and longitude).</td>
</tr>
<tr>
<td>○ Sample collection method.</td>
</tr>
<tr>
<td>○ Sample container description.</td>
</tr>
<tr>
<td>○ Collection dates and times.</td>
</tr>
<tr>
<td>○ Sampler name:</td>
</tr>
<tr>
<td>○ Was the sample(s) transported in a cooler box? Yes/No</td>
</tr>
<tr>
<td>○ Stream flow (at time of sampling).</td>
</tr>
<tr>
<td>○ Lapsed time from sample collection to delivery.</td>
</tr>
<tr>
<td>○ Sample temperature when received at the laboratory.</td>
</tr>
<tr>
<td>○ Physical and chemical data.</td>
</tr>
<tr>
<td><strong>Dilution water samples</strong></td>
</tr>
<tr>
<td>○ Source.</td>
</tr>
<tr>
<td>○ Sample collection method.</td>
</tr>
<tr>
<td>○ Sample container description.</td>
</tr>
<tr>
<td>○ Collection date(s) and time(s) (where applicable).</td>
</tr>
<tr>
<td>○ Sampler name.</td>
</tr>
<tr>
<td>○ Was the sample(s) transported in a cooler box? Yes/No</td>
</tr>
<tr>
<td>○ Pre-treatment.</td>
</tr>
<tr>
<td>○ Physical and chemical characteristics (pH, hardness, salinity, etc.).</td>
</tr>
</tbody>
</table>
Test report

Sample receipt
- Date of sample receipt at testing laboratory.
- Is the sample suitable for analyses? Yes/No
- Specify any abnormalities or departures from normal or specified conditions of test items

Sample reference details

Methods and test conditions
- Methods requested
- Toxicity test method used (title, number, source)
- Endpoint(s) of test
- Deviations from reference method, if any, and reason(s)
- Date and time test started and terminated
- Type and volume of test chambers
- Volume of solution used per chamber
- Number of organisms per test chamber and number of replicate test chambers per treatment
- Feeding frequency, and amount and type of food
- Acclimation temperature of test organisms (mean and range)
- Test temperature (mean and range)
- Test organism(s)
  - Scientific name, age, life stage and mean length and weight (where applicable)
  - Source
  - Diseases and treatment (where applicable)

- Associated water quality results, such as pH, conductivity, temperature, dissolved oxygen concentration and chlorine concentration should be reported with each sample tested for toxicity.
- Applicable Proficiency Testing Scheme reports and reference toxicity test results must be made available on request.
Reporting

- An extensive annual report (with trends) should be submitted to DWA.
- Review results every year.
  - Type of tests:
    - Include more sensitive test species.
    - Water vs sediment tests.
    - Acute vs chronic tests.
  - Frequency of tests:
    - More often – seasonable variability or process fluctuations.
    - Less often – no toxicity.
Non compliance

- DWA should decide on compliance limits.

**Example**

*Should the quality of the effluent or water in the ..... river downstream of the discharge be found to be unacceptable, even though the effluent which is discharged complies with the quality requirements specified in condition ..., the licensee shall immediately implement further measures to improve the quality of the effluent.*

- Investigate cause of toxicity.
- Retest sample.
- Check chemical results.
- Period to correct discharge.
- Fine or imprisonment.
Draft Implementation Plan

- Key success factors:
  - Development of toxicity test standards.
  - Adequate regulation.
  - Appropriate licence conditions.
  - Compliance criteria.
  - Legal action.
  - Strengthening national capacities.
Recommendations

To implement aquatic toxicity tests as part of the South African regulatory process the following actions are recommended:

- An in-depth analysis and classification of the numerous toxicity test procedures and methods to determine their suitability to application in the various fields of water use and discharge.
- The determination and implementation of compliance limits based on chemical and toxicity guidelines to ensure efficient monitoring and enforcement.
- Laboratory performance evaluation by compulsory participation in Proficiency Testing Schemes and follow-up training if performance is not up to standard.
- Incorporation of toxicity tests in formulation of environmental legislation and policy directives.
- Communication between the personnel driving the implementation at national level and the personnel enforcing the licensing conditions will be of the utmost importance.
Way forward

- The successful implementation of routine toxicity testing nationwide will depend on the interactive collaboration between government, toxicity test service providers and industry.

- A communication strategy that involves the general public, laboratories, municipalities and relevant government departments will aid in raising the profile of water quality testing.

- Toxicity testing laboratories need a legislative incentive, e.g. implementation of the DEEEP approach, to invest in capacity building.

- DWA personnel will have to be trained to include toxicity guidelines and testing in licensing conditions for effluent discharge and to enforce compliance with these conditions.

Aquatic toxicity testing in South Africa: Status of Aquatic Toxicity Testing in South Africa, 2011 (WRC report number: 1853/1/11)
THANK YOU