# Assessing and controlling the ecotoxicity of complex effluents

ENVIRONMENT AGENCY

## Glossary of terms

### Best Available Technique/Technology (BAT);

Process options that prevent or minimise pollution and can be implemented effectively. The BAT option should also consider economic and technical viability.

### Best Practicable Environmental Option (BPEO);

The most appropriate environmental option following an integrated approach for preventing or minimising pollution to air, land or water. The selected option will take into account the risk of transferring pollutants from one medium to another.

### Direct Toxicity Assessment (DTA);

The use of whole effluent ecotoxicity testing to help assess and control complex industrial and sewage treatment works effluents in the UK.

### Good Laboratory Practice (GLP);

A scientific data collection and management system, designed to minimise the chance of error and fraud, used to help ensure that new chemicals do not cause deleterious effects on human health or the environment. (Also see UKAS Accreditation).

### Integrated Pollution Control (IPC);

A pollution control and regulation regime introduced by the Environmental Protection Act, 1990. The provisions of the Act apply to prescribed processes that offer the potential for most environmental harm.

### Integrated Pollution Prevention and Control (IPPC);

A pollution prevention control and regulation regime introduced by the Pollution Prevention Control Regulations, 2000. The legislation is designed to prevent, reduce and eliminate pollution to all environmental media at source using BAT and through the prudent use of natural resources in order to move towards greater environmental sustainability.

### Regulatory Ecotoxicology Testing Quality Scheme (RETQS);

A scheme which aims to maintain and improve the reliability of ecotoxicity test data generated for DTA purposes. It does so through combining elements of Quality Assurance, Quality Control and a requirement to perform tests according to specified methods.

### Special Area of Conservation (SAC);

Areas designated for conservation under the EC Habitat Directive (e.g. estuaries), with the aim of maintaining or restoring those natural habitats and protecting species of European interest at those sites.

### Special Protection Area (SPA);

Areas which are considered internationally important sites for bird life. These sites are designated under the EC Wild Birds Directive.

### UKAS Accreditation;

A scientific data collection and management system, designed to minimise the chance of error and fraud, similar to that for GLP but with a wider remit than just the new chemicals safety assessment. (Also see GLP).

### Water Framework Directive;

European legislation setting out a framework for the protection of inland surface waters, transitional waters, coastal waters, groundwater's and the water needs of ecosystems reliant on these water sources. The aims of the directive are to prevent further degradation, protect, enhance and promote sustainable use of these waters.

*Front cover: Lemna minor (Duckweed) being used in an ecotoxicological test*

## Introduction

The Environment Agency is responsible for regulating many point-source discharges to controlled waters, with the aim of preventing pollution and protecting the environment. Traditionally, regulation has been based on the identification and control of specific chemicals or properties (for example, biological oxygen demand, pH and concentrations of specific substances) of the effluent. Although many discharges are effectively controlled in this way, some complex effluents need additional control measures to ensure an appropriate level of environmental protection. Complex effluents can contain hundreds of different chemical compounds. Their presence and interactions with each other are not always predictable. In addition, the chemical analysis of complex effluents can be costly.

To improve the assessment and control of complex effluents, the Environment Agency has developed and validated a whole sample biological effects testing approach (a Direct Toxicity Assessment approach). This can be used to provide complementary information to that provided by a chemical specific approach.

The purpose of this leaflet is to provide an introduction to the use of whole sample biological effects tests for effluent control. It is intended as an introductory guide for Agency regulatory staff, and operators of processes that discharge complex effluents.



*Complex effluent with the potential to cause harm*

*"Some complex effluents need additional control measures to ensure an appropriate level of protection for water quality."*

*Ecotoxic effects from pollution in the environment*

## The role of the Environment Agency in pollution prevention and control

*"The Environment Agency seeks to ensure that the environment, including fisheries, wildlife and amenities, is protected."*

As part of its approach to the control and prevention of pollution and in line with its environmental vision (Environment Agency 2000a), the Environment Agency seeks to ensure that the environment, including fisheries, wildlife and amenities, is protected, and that resources are effectively directed where necessary to improve the environment. Our role is to implement legislation and develop and use measures to prevent, minimise and mitigate the effects of pollution in England and Wales.

## The need for a Direct Toxicity Assessment approach

*Successful pollution prevention helps ensure a balanced ecology*

Water Resources Act consents, Integrated Pollution Control (IPC) authorisations and Integrated Pollution Prevention and Control (IPPC) permits are used to protect controlled waters from the potentially harmful effects of point-source discharges. At present, most discharge limits are based on the measurement of properties such as Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), pH or concentrations of other specified chemicals. These limits are derived

*Algae grown for use in culturing ecotoxicity test species*

from ecotoxicological, fate and behaviour data for individual substances, and are set to prevent harm to aquatic organisms and other natural resources. However, for complex effluents there are limitations to the chemical specific approach as follows:

- We do not know the exact composition of many effluents. Some substances present in an effluent originate from sources other than the process (for example, from cleaning processes, seepage from storage sites or run-off from hard surfaces) and some are breakdown products, so their presence can be unexpected. Sometimes these "unknown" substances can be more harmful than the "known" and controlled substances in an effluent;
- Where a substance can be identified in an effluent, there may not be sufficient toxicity information to derive a discharge limit, or the limit may be at a concentration too low to be effectively measured in the environment;
- A combination of substances can act together causing ecotoxicity in effluents and controlled waters even though the concentrations of single substances may be within discharge limits. No account is taken of substance interactions in establishing an Environmental Quality Standard for a single substance;

- It can be expensive to sample and analyse for the numerous substances in complex effluents, and to generate ecotoxicity data for each identified substance.

One solution to this problem is to use Direct Toxicity Assessment (DTA), as a complementary approach alongside a chemical-specific approach:

- DTA can be used to predict the potential for harm where the ecotoxicity of an effluent cannot easily be ascribed to the presence of a single regulated substance above a toxic concentration or control limit;
- DTA can offer a more cost-effective approach to the assessment of complex effluents than assessing numerous single chemicals for which ecotoxicological, fate and behaviour data are often not available.

*"One solution to the problem is to use Direct Toxicity Assessment (DTA), as a complementary approach alongside a chemical-specific approach."*

The limitations of a chemical-specific approach and the advantages of the complementary use of whole sample biological effects measures have been addressed in many other countries such as Australia, Canada, South Africa, USA, Sweden, Germany and the Netherlands. In the USA, there is more than 15 years' experience of using a whole effluent approach. For example, before whole effluent ecotoxicity limits were applied, 25 percent of effluents from regulated facilities in North Carolina, USA were predicted to be causing receiving water toxicity. However, since 1987, this percentage has decreased to 10 percent as a direct result of applying whole effluent ecotoxicity limits (Ausley 2000).

## The development of a Direct Toxicity Assessment approach

A methodology involving short-term lethal and sub-lethal biological effect measures have been developed by the Environment Agency. These have been successfully trialed in a collaborative Demonstration Programme with industry. When adopted this methodology will:

- enable the overall toxic burden from specific point-source discharges to be reduced;
- enable the size of zones of toxic impact to be reduced;
- help protect aquatic life in UK receiving waters.

The Agency is also developing methodologies to deal with longer-term sub-lethal effects and specific mechanisms of effect (for example, endocrine disruption). These methodologies relate to the survival, reproduction and growth of animals and plants.

*The source and nature of ecotoxic effects can be determined using a DTA approach*

## How should DTA be used, and by whom?

The recommendations from the Demonstration Programme to the environmental regulators indicated three priorities for the use of a DTA approach (UKWIR 2000a). These priorities were accepted by the Agency and are summarised as follows:

- Review of discharge consents and authorisations containing whole sample toxicity-based conditions with a view to ensuring that 'good practice' and consistency in approach is achieved.
- Target catchments with well-defined water-quality issues associated with short-term lethal and sub-lethal ecotoxicity from point-source discharges with a view to delivering further water-quality improvements.
- Ask operators of IPC/IPPC licensed processes with direct releases to receiving waters, and at greatest risk of causing environmental damage, to provide whole sample short-term lethal and sublethal ecotoxicity data as part of their licence application or review. This will improve the ecological relevance of the data used to assess the environmental impact of their processes.

Technical guidance is being prepared which will deal with both the generation of ecotoxicity data and the use of this data for effluent assessment and control purposes, (UKWIR 2000b, Environment Agency 2000b & 2000c). This includes steps to identify the source and nature of the toxicity.

The technical guidance should be followed in order to:

- help deliver environmental improvements;
- facilitate the most efficient use of resources;
- encourage an equitable and consistent approach.

A limited suite of tried and tested algae, invertebrate and fish ecotoxicity test methods using freshwater and marine species have been selected for use in the DTA approach. Advisory notes detailing modifications and additional procedures that need to be considered when using international test guidelines for effluent and receiving water assessments have been developed (Environment Agency 2000b). More comprehensive ecotoxicity method guidance has also been produced for laboratories wishing to develop an ecotoxicity effluent testing competency (Environment Agency 2000c).

The Environment Agency proposes to set up a Regulatory Ecotoxicology Testing Quality Scheme (RETQS) to ensure that the quality of data generated by these methods is suitable for regulatory decision-making. The scheme will require:

- testing to be conducted in accordance with approved method guidance and in compliance with a formal Quality System through Good Laboratory Practice (GLP) or United Kingdom Accredition Service (UKAS) accreditation;
- laboratories to be capable of meeting independently derived criteria for precision and accuracy.

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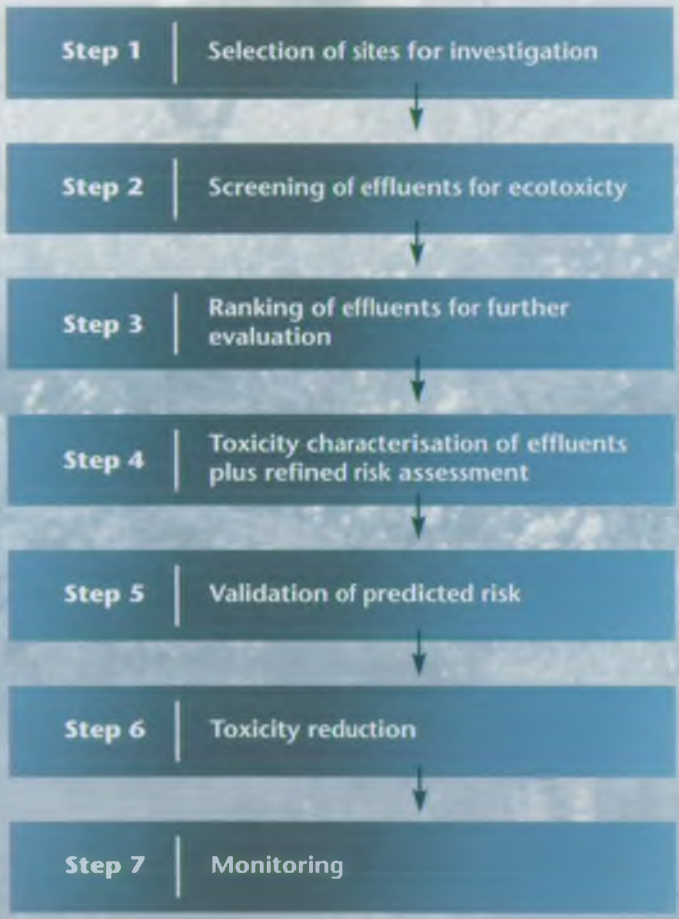
*Use of a zinc reference toxicant to help ensure the quality control of ecotoxicity data*

The key steps involved in using a DTA approach to deliver improvements in catchments with well-defined water-quality issues associated with short-term lethal and sublethal ecotoxicity from point-source discharges are given in Figure 1.

**Figure 1. Direct Toxicity Assessment: Key Steps**



A DTA approach is considered as the basis for a regulatory instrument with data on the ecotoxicity of the effluent being used to 'trigger' investigative work and subsequent prevention and improvement action.

Using information on the ecotoxicity of an effluent to 'trigger' improvement action by the discharger is more likely to lead to environmental benefit than using the information as a 'pass/fail' condition in licences. This is because the trigger approach provides flexibility for the discharger to find the most cost-effective solution, rather than imposing a solution that might not be in the long-term interest of either the environment or economy. This is particularly important in considering urban sewage treatment works effluents, as the operator does not have direct and immediate control over all inputs to the sewer.

*A complex effluent: the exact composition is often unknown*

There may be circumstances when the use of ecotoxicity information on the discharge as a pass/fail licence condition is required in order to gain and maintain public confidence. However, the reasons for adopting the pass/fail approach should always be made clear and even in these

circumstances the regulator should work with dischargers to ensure reasonable timescales for achievement of the limit.

The Environment Agency will encourage the voluntary use of a DTA approach by industry, particularly where a site operator has demonstrated a clear understanding of their environmental responsibilities and has an accredited environmental management system in place.

## Future developments of a DTA approach

*"The Environment Agency will encourage the voluntary use of a DTA approach by industry, particularly where a site operator has demonstrated a clear understanding of their environmental responsibilities."*

A DTA approach has other potential applications beyond the scope of those trialed in the DTA Demonstration Programme. Some of these are listed below:

- helping to protect against sub-lethal effects resulting from longer term exposure to complex effluent. This will ensure the delivery of the Environment Agency's aspiration to improve all controlled waters to a 'good ecological quality' in line with the proposed Water Framework Directive;
- delivering establishment of 'benchmark' toxicity levels for Best Available Technique (BAT) and Best Practicable Environmental Option (BPEO) for each industry sector;
- improved protection for environmentally sensitive environments such as a Special Area of Conservation (SAC) or a Special Protection Area (SPA).

Furthermore, biological effect measures can be developed and used to benefit the Agency's receiving water assessment, contaminated land and air-quality control duties.

Further information on the application of a DTA approach can be obtained by contacting the Environment Agency's National Centre for Ecotoxicology and Hazardous Substances. Telephone: 01491 828544.

*A DTA approach can help protect and improve the environment*

## References

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UKWIR, 2000a. *Recommendations from the Direct Toxicity Assessment (DTA) Demonstration Programme Steering Group to the Regulators.*

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